# ATLAS HANDBOOK ON CONCRETE CONSTRUCTION

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*on*
# CONCRETE CONSTRUCTION



THE STANDARD BY WHICH ALL OTHER MAKES ARE MEASURED
ATLAS

The Atlas Portland Cement Company

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Boston  Albany  Philadelphia  Chicago  Des Moines
Omaha  Kansas City  Oklahoma City
Waco  Birmingham

## FOREWORD TO EARLY EDITIONS

THE purpose of "The Atlas Handbook on Concrete Construction" is to provide, in convenient form, practical information on concrete—both plain and reinforced. It is written from the practical rather than the technical standpoint for the average builder in concrete.

Realizing the impossibility of giving in a book of this size detailed information about building many different structures, we have covered in considerable detail, the subjects of concrete, reinforced concrete, and forms, in Chapters I, II and III. The builder will be able to adapt this information to the particular work to be handled.

## FOREWORD TO REVISED AND ENLARGED EDITION—1927

In this edition various parts of the text have been brought up to date; the number of estimating tables has been increased; and a chapter on the uses and manipulation of Atlas Lumnite Cement has been added.

Further information will be gladly furnished. The Technical Department, consisting of a staff of trained engineers is maintained for the purpose of cooperating with builders in concrete.

You are under no obligation for this service. The company furnishes this book and the information and assistance referred to above, without guaranty, warrant or other obligation on its part.

THE ATLAS PORTLAND CEMENT COMPANY

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# CHAPTER I

## CONCRETE—THE MODERN CONSTRUCTION MATERIAL

Upon the builder often rests the responsibility for choosing the type of construction as well as for the proper execution of the work. His advice is sought as to what material is best fitted for the work in hand.

The builder who is looking toward future business, has a sincere desire to serve the owner's interest in selecting the construction which will give best service. Therefore the owner should be informed of the following outstanding advantages of concrete:

**Concrete is fire resistant.**—It successfully resists severe conflagrations—it cannot burn. When used for buildings, it affords protection against loss of life as well as property.

**Concrete is permanent.**—It does not rot or decay; therefore it requires no repairs and does not involve expense for painting or other upkeep.

**Concrete is strong**—and grows stronger with age. This means:

(1) Great load carrying capacity. Reinforced concrete structures have been designed for the heaviest of loads.

(2) Long spans which allow maximum window space with good lighting. Window area in concrete buildings is normally 50 to 85% greater than in other types.

(3) Resistance against vibration. No other type of construction equals reinforced concrete in rigidity.

**Concrete is reasonable in cost.**—It compares favorably with other forms of construction in original cost, representing

lowest cost as compared not only with fireproof buildings, but likewise with mill construction generally. In final cost concrete easily excels, for little or nothing is added to the original cost because of repairs or maintenance charges.

**Concrete means quick construction.**—Details of designs are simple and the designs are quickly turned out. Cement and reinforcing steel can be obtained from stock with no waiting for materials. Sand, pebbles and crushed stone which form the bulk of concrete are usually obtained locally.

**Concrete meets architectural and engineering requirements,** satisfying all demands as to appearance, utility and economy.

## SELECTION OF MATERIALS

The quality of concrete depends upon the materials used, the manner in which they are used, and the way in which the concrete is treated after it is made. The best concrete results only from careful selection and proportioning of materials, proper mixing and placing, and thorough curing.

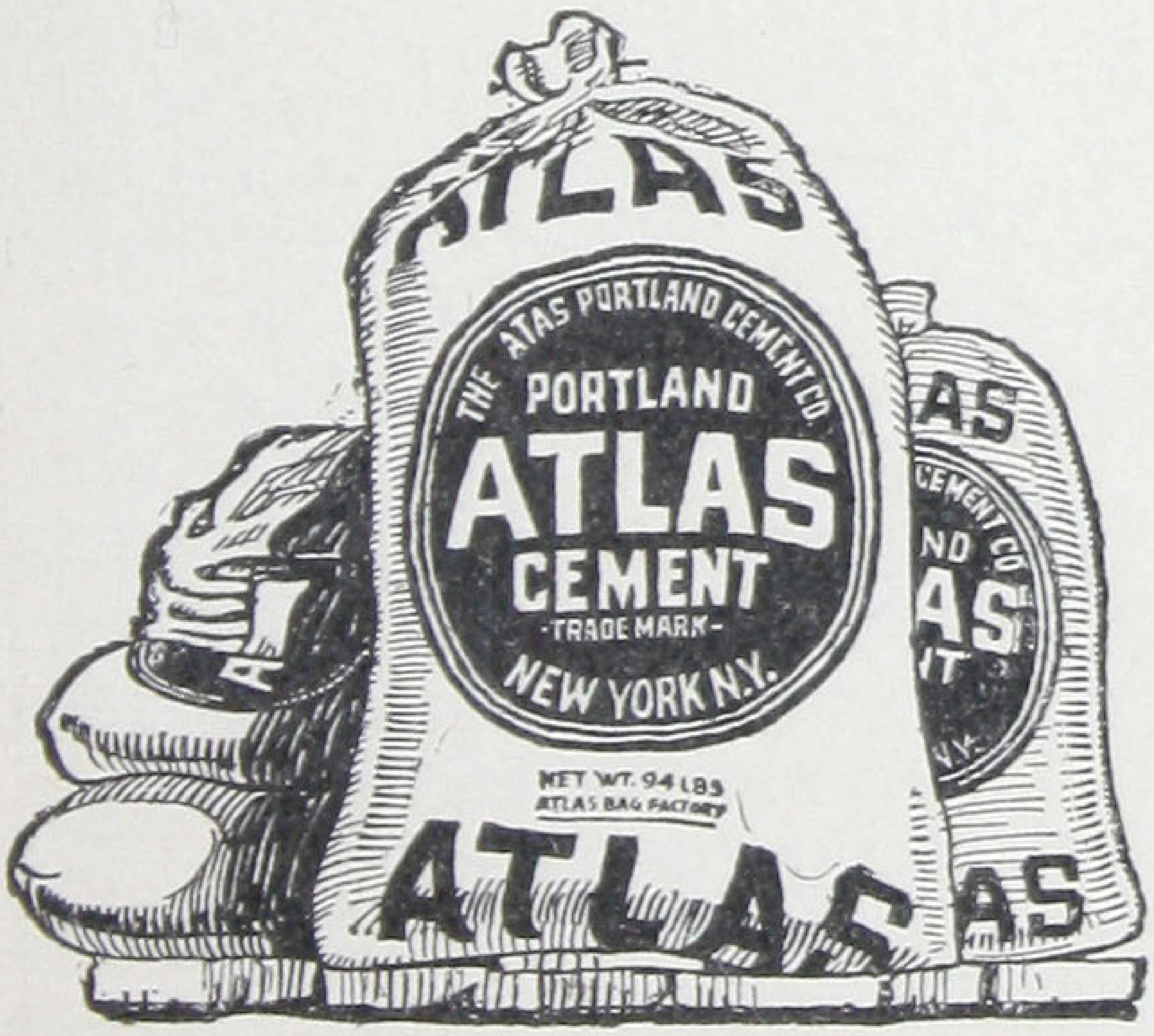
### Cement

The only scientifically made ingredient of concrete is the cement. The other materials—sand, pebbles or crushed stone, and water—are used as they come from nature and may vary greatly in quality.

Atlas Portland Cement is a carefully made, thoroughly reliable product, guaranteed to meet all of the requirements of the standard specifications for portland cement. Its quality is definitely established by exhaustive tests before it leaves the mill. It is always uniform and entirely dependable.

The word "portland" signifies only the kind of cement, not the brand. All cements used for important work are portland; the brand name should therefore, always be given. The name "portland" was given to cement by its discoverer, because of its resemblance, when hardened, to a very hard stone quarried on the Isle of Portland near England.

A barrel of cement weighs 376 pounds net and equals four bags of 94 pounds each, each bag containing approximately one cubic foot. Cement is generally shipped in cloth or paper bags, sometimes in bulk on large jobs, and for export in wooden barrels.




ATLAS PORTLAND CEMENT
*"The Standard by which other makes are measured."*

## AGGREGATES

The inert materials, such as sand, pebbles or crushed stone, mixed with the cement to make concrete, are called aggregates. Aggregates are classified as "fine" and "coarse."

**Fine aggregate** is sand or stone screenings which will pass through a screen with one-quarter inch openings.

**Coarse aggregate** is commonly pebbles or crushed stone retained on a screen with one-quarter inch openings. The maximum size of pebbles or pieces of stone depends upon the character of the work, and usually ranges from three-quarters of an inch to three inches.

### Sand—(Fine Aggregate)

Too much care cannot be used in selecting a good fine aggregate. It should consist of clean, natural sand or screenings from hard, durable crushed stone. It should be composed of quartz grains or other hard material, running in size from fine to coarse.

Sand must be clean, otherwise the quality of the concrete will suffer. The impurities that occur in sand are loam, clay,

mica and organic matter. Sand containing more than 3% (by weight) of loam or clay should not be used unless washed. Loam can be determined as described below. Mica is very injurious if it occurs to the extent of over 1%.

By organic matter is meant sewage, vegetable matter, tannic acid, manure and other substances of this kind, all of which are very objectionable. Organic impurities can be determined as described below. Sand containing these impurities but meeting requirements of good sand in other respects, can sometimes be used if washed, page 5.

In some sections where a sandy soil prevails, builders frequently use in concrete the sand obtained from the cellar excavation. *This practice cannot be too strongly condemned.* Sand obtained in this way comes from a point at the most five or six feet below ground surface and hence likely to be contaminated by organic impurities from the layer of vegetation at the surface. A costly failure of concrete from the use of such sand may amount to many times the fancied saving on the cost of securing good sand.

A well-graded sand is better than either a fine or a coarse because it will make a stronger and denser concrete. Fine sand of uniform grain, such as beach sand, is not desirable for concrete. Sand should be graded, i. e., the particles vary in size from fine to coarse with the larger particles predominating.

## How to Determine the Amount of Loam

Use a pint bottle and put in sand to the height of four inches, then fill the bottle almost full with water. Shake thoroughly and allow to settle over night. The loam and fine material will settle on the top and the thickness of this layer should not be over one-eighth of an inch. See Fig. 1.

## How to Determine Organic Impurities*

Fill a 12-ounce prescription bottle with sand to the 4½-ounce mark. Then add a 3% solution of caustic soda known as sodium hydroxide (which you can buy at nearly all drug

* From the Proceedings of the American Society for Testing Materials.

stores) until the volume of sand and solution, after shaking, amounts to 7 ounces. Shake the contents thoroughly and let stand for 24 hours. If the liquid resulting from this treatment is colorless, or has a light yellowish color, the sand may be considered satisfactory in so far as the organic impurities are concerned. If there is a dark colored liquid (above the sand) it indicates that the sand contains organic impurities and must not be used unless these impurities are washed out. See Fig. 2.

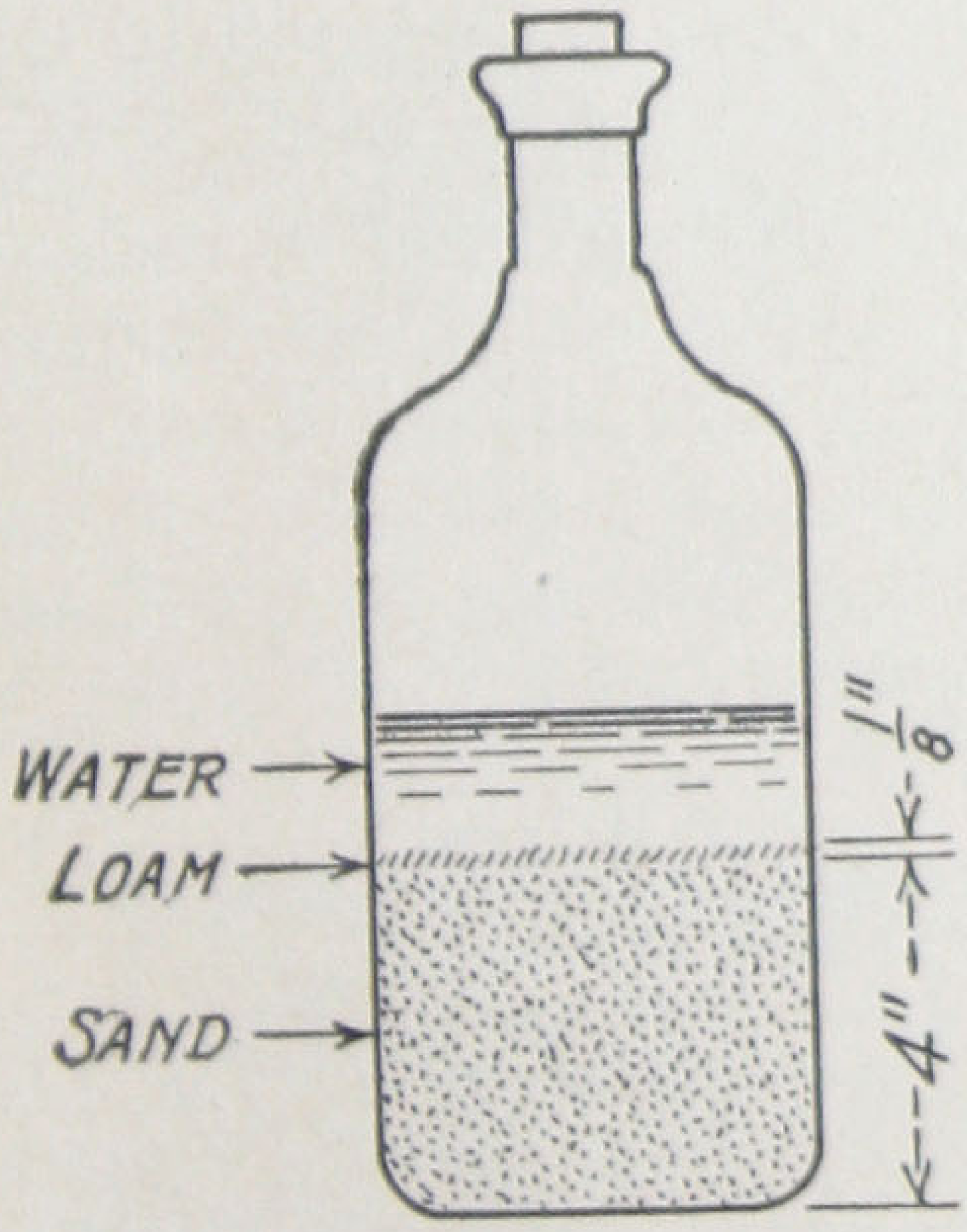



Fig. 1.—Test for determining amount of loam in sand.

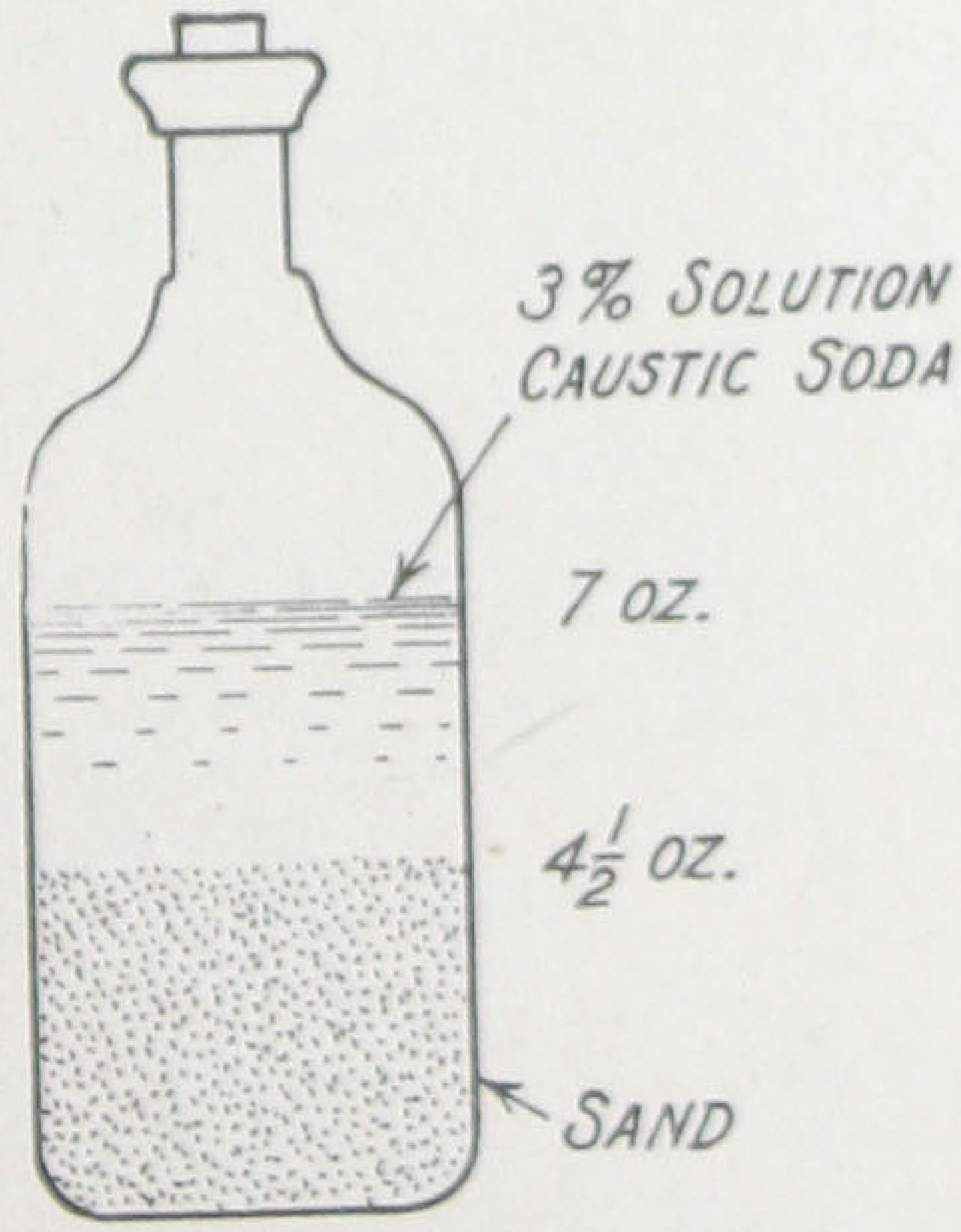



Fig. 2.—Simple field method of testing sand for organic impurities. Known as the Colorimetric Test.

## Sand Washing

Sand which is dirty may often be made suitable for concrete by washing.

A device which can be used advantageously for washing sand or washing and screening bank-run gravel on small jobs is shown in Fig. 3.

## Pebbles or Crushed Stone (Coarse Aggregate)

The pebbles or crushed stone must be clean, hard, tough and graded in size, free from vegetable or other organic matter.

The material should be sufficiently hard so that the strength of the concrete will not be limited by the strength of the aggregate. Flat, elongated particles are unsuitable.

The size of the coarse aggregate depends upon the nature of the work. For thin walls and other construction in which the concrete must be worked around reinforcing steel, the coarse aggregate should run from one-quarter inch to one inch in size. For mass concrete work the coarse aggregate may well run from one-quarter inch to three inches in size. The best concrete results when the pebbles or stone are graded in size. Well-graded aggregates, i. e., varying in size from fine to coarse, give stronger and more watertight concrete.

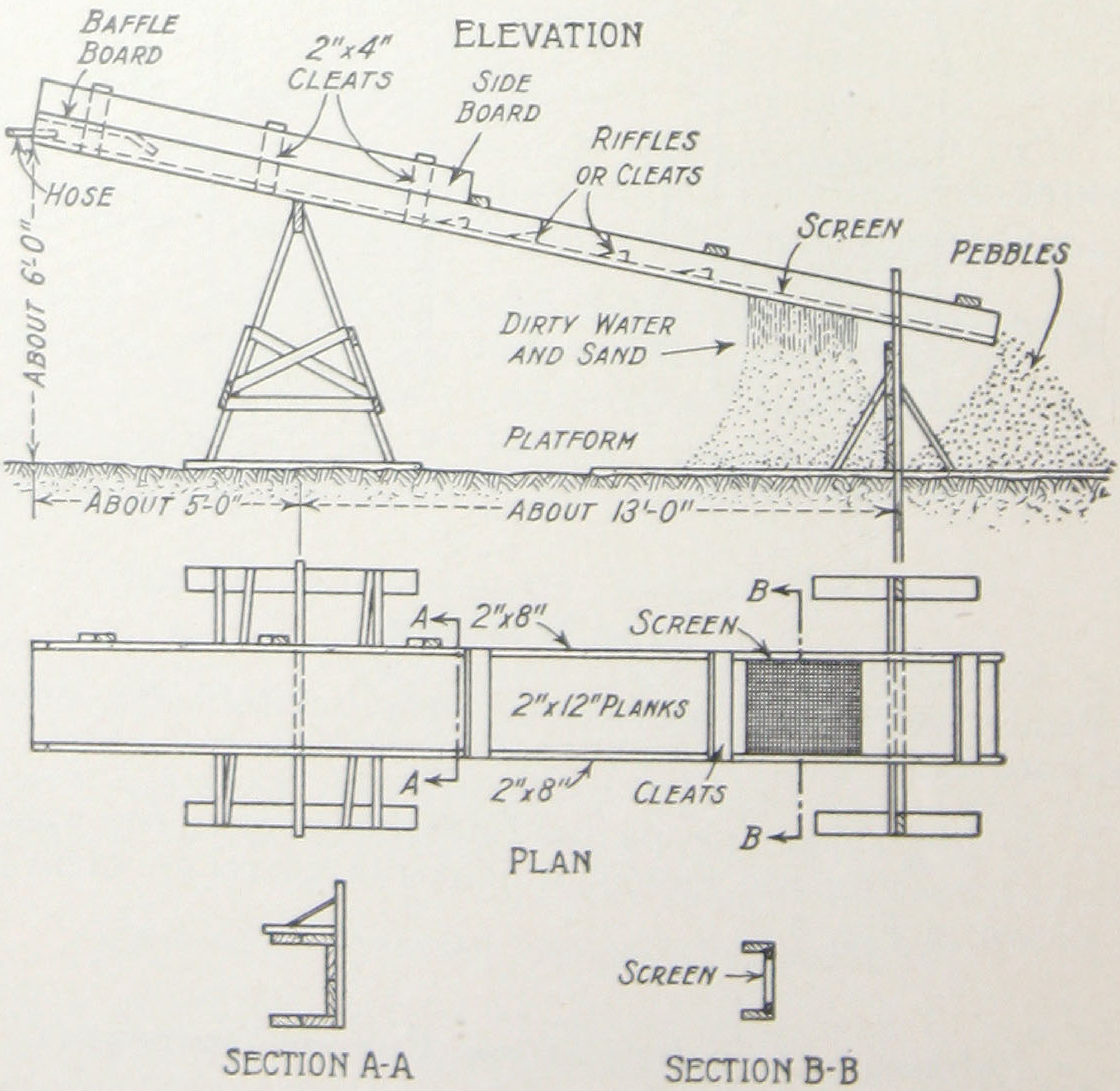



Fig. 3.—A simple washing trough with screen at lower end, by means of which bank run material can be washed and at the same time sand separated from the pebbles.

The danger of impurities in pebbles or crushed stone is not nearly so great as in sand. It is very important, however, to make sure that the coarse aggregate is hard and durable.

## Bank-Run Gravel

Bank-run gravel is a mixture of sand and pebbles taken from the bank or pit, without screening to separate the pebbles from the sand.

In bank-run gravel, the percentage of sand is usually higher than that required in a correctly proportioned mixture, and is liable to vary greatly in different parts of the bank. The material must, therefore, be screened through a one-quarter inch mesh screen; the sand and pebbles thus separated can then be measured into the concrete in the correct amounts. Washing and screening at the same time may be accomplished by using the device shown in Fig. 3.

## Use of Large Stones in Mass Concrete

In mass work, such as bridge abutments, large stones six inches or more in size are sometimes used to save on the quantity of concrete. The concrete is mixed and placed in the regular way, and the stones are then imbedded in it one at a time. There should be at least six inches of concrete between the stones and the forms. Not over 30% of the mass should consist of such large stones.

## Cinder Concrete

The term "Cinder Concrete" is applied to concrete made of cement and cinders. Cinders, in order to be suitable for concrete should be hard burned boiler cinders, contain no fine ash, and should have been thoroughly wetted at least twenty-four hours before using, so as to slack out any free lime and neutralize the effect of any sulphur present. Household ashes are too fine and powdery and should never be used.

Cinder concrete is employed for certain classes of work, such as floors that are not designed for carrying heavy loads,

and for fireproofing structural steel. The proportion ordinarily used is one part of cement to five parts of cinders. The value of cinder concrete lies chiefly in its cheapness and light weight.

### Slag Concrete

Blast furnace slag has found an increasing use as a coarse aggregate for concrete. The slag particles are extremely hard, and, because of their pitted irregular surfaces, are firmly held in the matrix of cement and sand. Formerly it was considered necessary to caution against the presence of sulphur, but present day knowledge shows this caution to be unnecessary, so that the Bureau of Standards states that the sulphur content need not be specified. The American Society of Testing Materials in their Tentative Specifications require a minimum weight of sixty-five pounds per cubic foot for slag in concrete not subject to abrasion and not less than seventy pounds in concrete floors or roads.

### Water

Water to be suitable for mixing concrete, must be free from acid, alkali, oil or any other impurity. Sea water should not be used unless it is absolutely impossible to secure fresh water. It is very important to use only clean water.

The amount of mixing water is of utmost importance and is treated in the section on Proportioning which follows.

## PROPORTIONING CONCRETE

The proportions of materials for concrete are always stated by volume, such as 1:2:4, meaning one part of cement, two parts of sand and four parts of pebbles or crushed stone. It must be remembered when using a mixture of sand and pebbles properly proportioned, that about a 1:5 mixture (one part of cement to five parts of mixed aggregates)—not a 1:6—is the equivalent of a 1:2:4.

For each class of work experience has shown that a certain mixture gives the best results:

1:1½:3 or 1:2:3 mixture for concrete roadways, one course

walks, floors, pavements; some watertight work such as tanks, reservoirs, swimming pools and cisterns; some cast work such as sewer pipe, drain tile and fence posts.

1:2:4 mixture for reinforced concrete work such as beams, columns, floors, walls and general reinforced work; for work subjected to a moderate amount of water and dampness; for work subjected to vibration such as bridges and engine foundations; for silos, elevators, coal bins.

1:2½:5 mixture for base course for sidewalks, floors and pavements, basement walls not necessarily watertight, foundations, mass dams, retaining walls and wing walls of bridges and culverts.

1:3:6 mixture for mass construction and large footings and foundations.

If it is desired to determine exactly what mixture, with the materials available, will give the best and most dense concrete, the principle involved is that of so proportioning the materials as to secure a complete filling of the voids. Sand, pebbles or crushed stone have included in their volume, spaces or voids. In the perfect concrete the voids are completely filled, the proportions being such that the voids in the coarse aggregate are filled by the fine aggregate, and the voids in the fine aggregate are filled by the cement. A certain proportion must be determined so that this condition will exist so far as possible from a practical standpoint.

It is evident that if the pebbles or crushed stone are graded, containing large and small particles of various sizes, the smaller particles serve to fill the voids of the larger, and less sand is needed; likewise, with a graded sand, less cement is required. Hence, in the use of well-graded aggregates, properly proportioned with a certain amount of cement, better strength and density are obtained than with poorly-graded aggregates.

Rough method for determining amount of voids and proportions for concrete mixtures is: Take a large pail or can of known volume—say five gallons. Fill with dry sand to be used. Pour in water, keeping accurate check on amount of water until it flushes to top of sand. Amount of water needed represents percentage of voids in sand; i. e., if two

gallons of water were needed, percentage of voids is two-fifths, or 40%. These voids must be filled by cement with a little to spare. Therefore, use say 50% cement, or one-half the volume of sand; or one part cement, two parts sand. Determine voids in the stone or pebbles by same methods; i. e., if we found 40% voids in the stone we should fill these voids with sand, with a little to spare. We would then use 50% of sand, or twice as much stone as sand. Therefore, this mixture would be one part cement, two parts sand, and four parts stone or pebbles.

Scientific methods of proportioning consist of determining the "fineness modulus" of the fine and coarse aggregates by sieve analysis and proportioning in accordance with results so as to obtain a mixture which has the greatest possible density. For detailed information on the design and control of concrete mixtures, write to the Technical Department of The Atlas Portland Cement Company.

## Amount of Water

An excess of water weakens the concrete; an insufficient amount prevents thorough mixing. Water should be measured with the same precision as other materials.

An example of the effect of water is illustrated by the table on next page. The tests are at the age of twenty-eight days, using the same mix but varying the amount of water. This table shows that the greatest strength is obtained when the least amount of water is used. It must be remembered however, that too little water can be used thus preventing proper placing of concrete.

Using 5¾ gallons of water per bag of cement a strength of 2770 pounds per square inch is obtained; whereas, when using 10 gallons of water the strength diminishes to 830 pounds per square inch, or in other words, only 2/5 of the strength is obtained.

The injurious effect of water is especially noticeable in the case of concrete walls. Too much water brings a mixture of the floury part of the cement and water to the surface and at the end of the day's work this forms a layer of white material

**TABLE 1**

| Gallons of Water per Bag of Cement | 28-Day Compressive Strength Pounds per Square Inch |
|---|---|
| 5.75 | 2770 |
| 6.0 | 2600 |
| 6.25 | 2400 |
| 6.5 | 2250 |
| 7.0 | 1950 |
| 7.5 | 1670 |
| 8.0 | 1470 |
| 9.0 | 1100 |
| 10.0 | 830 |
| 12.0 | 480 |
| 15.0 | 200 |

known as laitance. This laitance prevents the proper bonding of more concrete placed thereon and constitutes a plane of weakness. It is especially injurious if it occurs in tanks or dams, where water-tight construction is necessary. When laitance forms it should always be removed by scraping before new concrete is placed.

The importance of the water content in concrete cannot be over emphasized and the best contractors are using the minimum amount of water consistent with allowing the concrete to be properly transported and deposited in the forms. A rich mixture requires less water to give the required plasticity, hence such a mixture has added strength because it contains less mixing water.

## The Slump Test

The consistency of concrete or, in other words, the amount of water tc be used, may be checked by means of what is known as a slump test.

The slump test requirement is intended to insure concrete mixed with the minimum quantity of water to produce a mixture with the necessary plasticity or workability.

In determining workability, the newly mixed concrete shall be placed in a truncated cone-shaped metal mold 12 inches

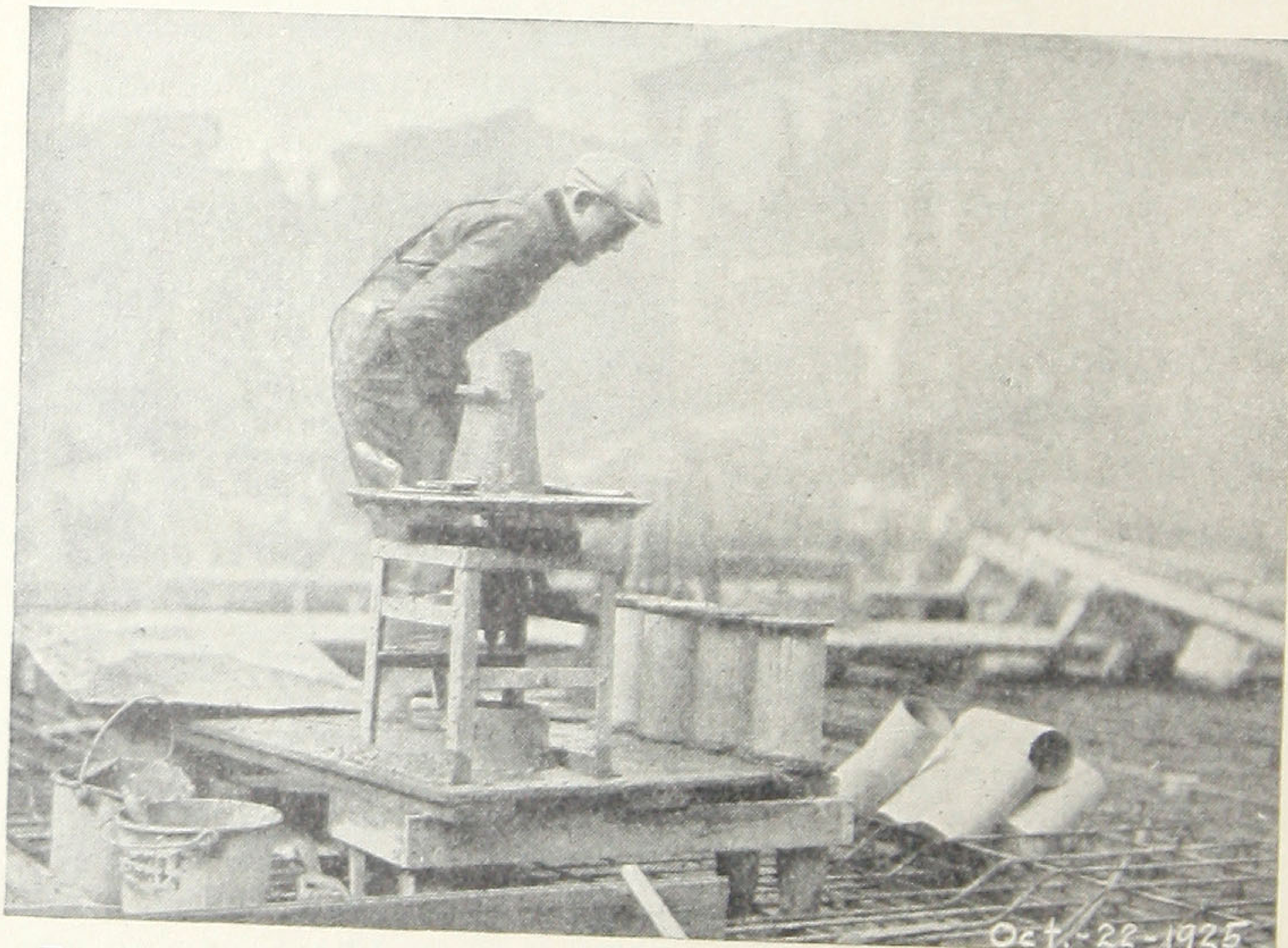



Fig. 4.—Apparatus for making the Slump Test on concrete. Above is shown the table in position at point where concrete is deposited. Notice cylinders of concrete which afterward will be tested for compressive strength. Below is shown method of measuring slump of cone after mold is lifted.

high, 8 inches in diameter at the base, and 4 inches in diameter at the top, and provided with handles at the sides as shown in the illustration. The concrete shall be lightly tamped with a rod as it is placed in the mold; which, when filled, shall be immediately removed and the slump or settlement of the concrete noted.

Concrete such as is used for ordinary reinforced concrete work should show a slump of 8 inches; i. e., the 12-inch cone of concrete is only 4 inches high after the removal of the mold. For certain classes of work where the concrete does not need to be made so wet, because of the absence of reinforcement, the allowable slump is much less, 2½ inches being about the right amount for ordinary plain concrete work such as floors, sidewalks, driveways, footings and basement walls.

## STORING AND HANDLING OF CEMENT, SAND AND STONE

Careful storage of materials pays. Even on small jobs many tons of concrete materials must be unloaded, stored, placed in the mixer, elevated and distributed. If one handling can be eliminated, or if only a few cents a ton can be saved through proper arrangement, the result will be very noticeable in the profit or loss record.

Although on a small or medium size building job it does not pay to lay out an elaborate storage and handling plant, some attention should be given to selecting convenient locations for various materials.

### Storing Cement

The first thing in connection with the storage of cement on the job is to keep it absolutely dry. If the job is to last over two weeks, it is a good plan to provide a dry weathertight storage shed at some convenient location. Where the con-

Fig. 5.—Shelter for cement at mixer. Capacity about 250 bags. Roof is made of slats and tar paper; sides of loose canvas. Notice floor raised off ground on mud-sills

creting will be finished in one or two weeks a temporary shelter such as shown in Fig. 5 may be built at the mixer. This holds about 250 bags of cement, which provides ample reserve in case any delay should occur in hauling. It is the practice, however, to make the shelter much smaller and in some cases to merely provide a tarpaulin in case of rain to throw over the 20 to 30 sacks which are kept at hand.

Cement must be kept off the ground no matter what arrangements are made for its storage.

For handling cement in bags from storage house to mixer a two-wheel warehouse hand truck or wheelbarrow is best for distances up to about 200 feet. An average load is 4 to 6 bags.

## Sand and Stone

In order to cut down length of wheelbarrow runs, the sand and stone piles should be located close to the mixer. Since in the majority of cases about twice as much stone is used as sand, the stone pile should be located closest to the mixer.

Where there is plenty of room, the sand and stone is stored in low piles just as dumped from the bottom-dump or end-dump wagons or trucks.

Where space is at a premium, temporary wooden bins allow the materials to be piled higher and confined to a smaller ground space. For most ordinary jobs this is not justified, unless storage space is unusually limited.

The Atlas Portland Cement Company will be glad to offer suggestions on storage bins and on economical storage and handling of materials for larger work than treated in this book.

## MIXING AND PLACING

Hand mixing is resorted to only when a very small quantity of concrete is to be mixed. For even small jobs a good mixer represents economy in labor and better quality concrete.

### Mixer

The mixer should be of batch type with a capacity of at least a one-bag batch of 1:3:6 concrete. A mixer of this size will take a one-bag or a one and one-half bag batch of 1:2:4 mixture. However, it is well to avoid when possible a split-bag batch, since using part of a bag tends to lead to inaccuracies in proportioning.

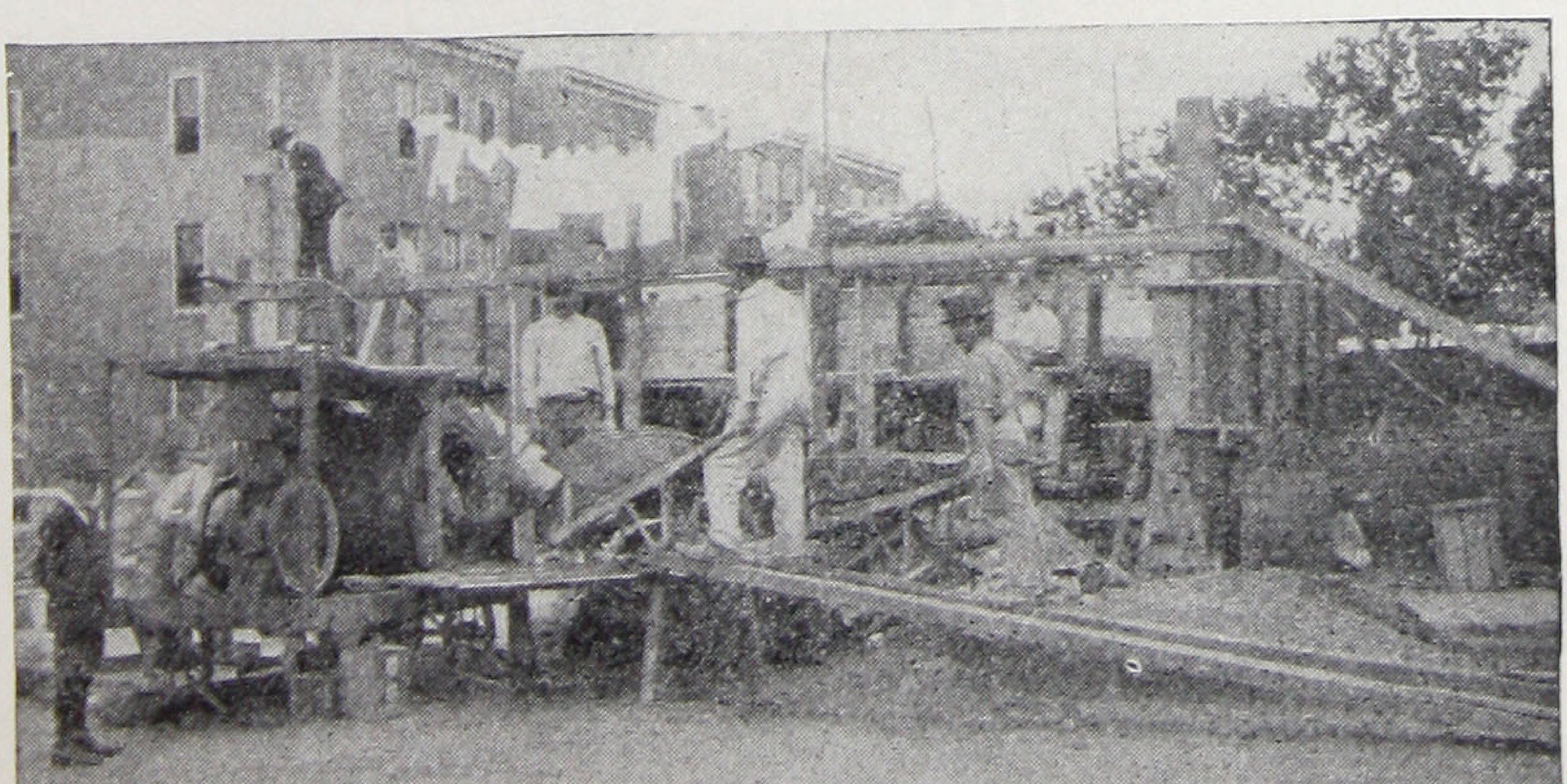


Fig. 6.—Small gasoline driven concrete mixer. Notice necessity for runways because mixer is not equipped with elevating loader skip.

All things considered, an elevating loader-skip is a good help to most mixers except where mixer can be located below the wheeling level for sand and stone.

## Water Supply

The water supply for the mixer should come through a 1½-inch pipe, or better, a 2-inch pipe. Not only is it extremely important from the standpoint of securing good concrete, that the amount of water and therefore, the consistency of each batch should remain uniform, but also from considerations of economy and increase of mixer output. Hence, some means of securing a regulation of the amount of mixing water per batch is very desirable. (Fig. 7.)

Many concrete mixers may be purchased equipped with an automatic water measuring drum attached permanently to the mixer. These are so arranged as to allow just the required amount of water to flow into the tank for each batch.

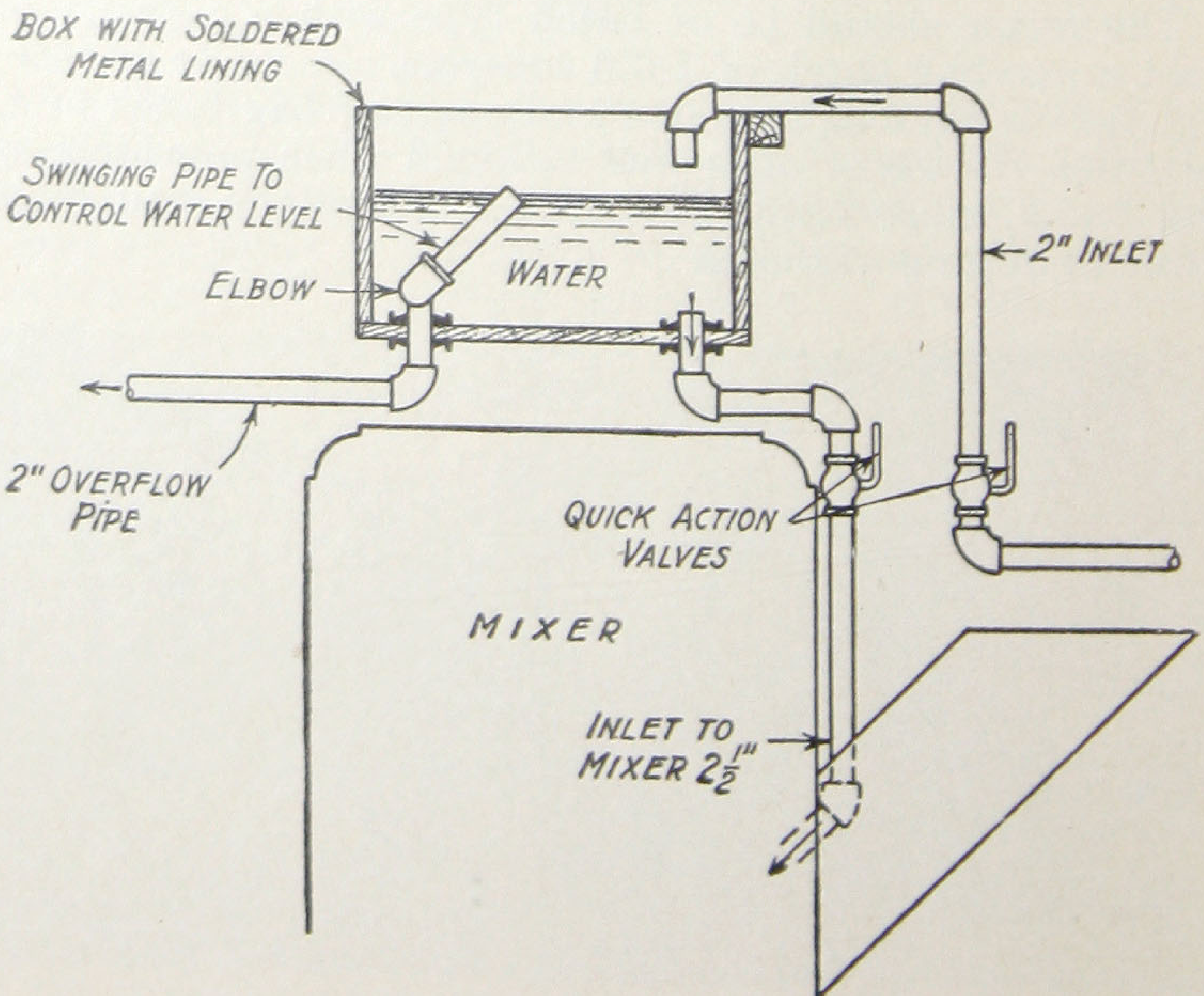



Fig. 7.—Device for measuring mixing water for concrete mixers not equipped with measuring apparatus. It is best to purchase mixer already equipped.

**TABLE 2**
**DATA ON MIXING CONCRETE**
**Dimensions for Bottomless Measuring Boxes of Various Capacities**

| Capacity in Cubic Feet | INSIDE MEASURE | | |
|---|---|---|---|
| | Length Inches | Breadth Inches | Height Inches |
| 1 cubic foot | 12 | 12 | 12 |
| 1¼ cubic feet | 15 | 15 | 9⅝ |
| 1½ cubic feet | 15 | 15 | 11½ |
| 1¾ cubic feet | 15 | 15 | 13½ |
| 2 cubic feet | 18 | 18 | 10⅝ |
| 2¼ cubic feet | 18 | 18 | 12 |
| 2½ cubic feet | 18 | 18 | 13⅜ |
| 2¾ cubic feet | 18 | 18 | 14⅝ |
| 3 cubic feet | 18 | 18 | 16 |

## Mixing

For charging the mixer a wheelbarrow is generally used. The ordinary wheelbarrow load of sand or stone is 2 cubic feet. A deeper barrow which holds 4 cubic feet may be obtained, and these sometimes are used although rarely filled with over 3 feet of material. Fig. 8 shows a bottomless measuring box which assures the correct amounts of materials.

Table 2 gives the dimensions for bottomless measuring boxes of various capacities.

Where wheelbarrow measurement of sand and gravel is to be permitted, the capacity of the wheelbarrow should first be found by the use of a measuring box.

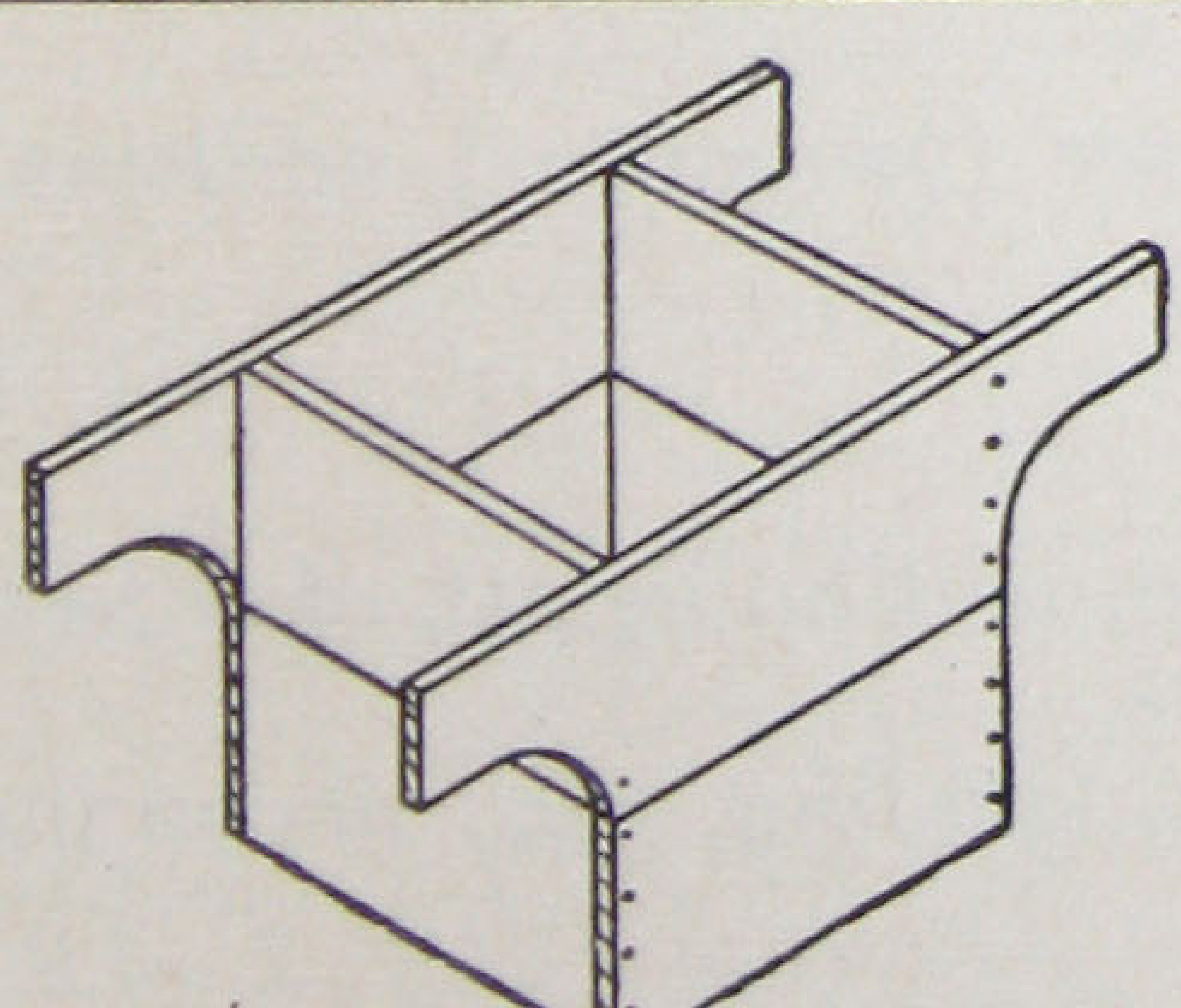


Fig. 8.—Bottomless measuring boxes for sand and stone should be used for accurate measuring; measuring by shovelsful is very inaccurate. Wheelbarrow measurement should be checked occasionally by throwing the box on the wheelbarrow and thus filling the barrow with a measured quantity.

## Concreting Gang

The following paragraphs are not intended for definitely specifying the size of the gang for each job. Only a basis is given for estimating the organization needed for the average or medium sized job. Let us assume that a one-bag batch of 1:2:4 concrete is to be mixed. Then we need one barrow of sand and 2 barrows of stone for each mix. This means three wheelers, and unless the distance from the sand and stone piles to the mixer is very short it is a good plan to have two extra shovelers.

At the mixer if it is gasoline driven, we need one man to attend to the engine, discharge the mixer and act as a general mixer foreman. One man attends to dumping in cement and regulating water and one man to bringing up cement to the mixer, sorting and bundling empty bags, etc.

For distributing the concrete it is difficult to determine beforehand just how many men will be needed—it all depends on how far the concrete must be wheeled and how easily it can be dumped into place. Three wheelbarrows will take care of each batch, but it probably will be necessary to have extra barrows so that there will be no mixer delay.

Charging mixer—

2 wheelers on stone (possibly 1 loader).
1 wheeler on sand (possibly 1 loader).

At mixer—

1 engineer or mixer foreman.
(If steam driven, add 1 fireman.)
1 cement and water man.
1 man bringing cement to mixer (probably 1 additional on sorting bags, etc.).

Distributing concrete—

3 wheelers (possibly more, dependent on length of wheel).
1 man helping to dump barrows.
Extra men shoveling, tamping, spading, etc., depending on character of work.

Total, approximately 12 men.

## Output of Concrete

For conservatively estimating output, an average time for each batch should be from two to three minutes. This means actual mixing of at least one minute. Table 3 gives output for various proportioned batches on this assumption.

**TABLE 3**

**Hourly Output of Concrete for Various Proportions Based on Average Time per Batch**

| Proportions, 1-Bag Batch | Aver. Time per Batch 2 Minutes | Aver. Time per Batch 3 Minutes | Aver. Time per Batch 4 Minutes |
|---|---|---|---|
| | Cubic Yds. | Cubic Yds. | Cubic Yds. |
| 1:1½:3 | 4.0 | 2.6 | 2.0 |
| 1:2:3 | 4.3 | 2.9 | 2.2 |
| 1:2:4 | 5.0 | 3.3 | 2.5 |
| 1:2½:4 | 5.4 | 3.6 | 2.7 |
| 1:2½:4½ | 5.7 | 3.8 | 2.9 |
| 1:2½:5 | 6.0 | 4.0 | 3.0 |
| 1:3:6 | 7.1 | 4.7 | 3.5 |

For a two-bag batch multiply quantities by 2, and for three-bag batch multiply by 3, etc. Of course, a larger batch will require more men supplying the mixer.

Taking an average time per batch of 3 minutes, which is fair for the medium size job, the output of the gang listed on a 1-bag, 1:2:4 mix would be 26.4 cubic yards for an 8-hour day.

**TABLE 4**

**Computing Daily Yardage of Concrete Mixed and Placed**

| Proportions | Amount of Concrete in a 1-Bag Batch | |
|---|---|---|
| | Cubic Feet | Cubic Yards |
| 1:1½:3 | 3.53 | .131 |
| 1:2:3 | 3.90 | .145 |
| 1:2:3½ | 4.22 | .156 |
| 1:2:4 | 4.50 | .167 |
| 1:2½:4 | 4.88 | .181 |
| 1:2½:4½ | 5.17 | .192 |
| 1:2½:5 | 5.44 | .202 |
| 1:3:5 | 5.81 | .215 |
| 1:3:5½ | 6.11 | .226 |
| 1:3:6 | 6.38 | .236 |

*See next page for example of using this table.*

Example: Your mixer has turned out 164 two-bag batches of 1:2½:5 concrete and you want to know how much this amounts to in cubic yards. Table 4 gives .202 cubic yards for a one-bag batch, so we multiply .202 by 2 to give us the quantity for a two-bag batch, and this by 164 batches to get the total yardage. Thus: .202 x 2 x 164 = 66.2 cubic yards.

Another method for arriving at the same result is to determine from Table 33, page 138, the number of bags of cement required for a cubic yard of mixed concrete. Then divide this figure into the number of bags used (by counting empty bags) and the result will be the number of cubic yards mixed.

Example: As above, 164 two-bag batches means that there should be 328 empty bags. A 1:2½:5 mix requires about 5 bags per cubic yard. Dividing 5 into 328 gives almost 66 cubic yards of mixed concrete. Bear in mind that all such quantities are only rough approximations—variations in aggregates may make these quantities too large or too small.

## Placing

For the small or medium size job handling the concrete must meet one of two general conditions:

1. Where concrete is deposited below, or at about the same level as the mixer.

2. Where concrete must be elevated above the mixer level: for instance for walls and floors above ground.

For the first condition, no special arrangement need be made, the concrete being discharged directly from the mixer into wheelbarrows or carts—"concrete buggies." (A concrete buggy is shown in Fig. 9.) The concrete is then wheeled along plank runways to the proper point and dumped into place. Where the concrete is to be placed in foundations or footings below ground level, simple board chutes may be used for chuting it into place. Such chutes are made with a flared upper end for convenience in dumping the barrow or buggy directly into them.

For the second condition, where the concrete must be ele-

vated, some special provisions are made. Where the job is a one-story building, such as a garage, dairy barn or store building, and the concrete must be elevated not more than 10 or 15 feet above ground level, inclined runways for wheeling the concrete up to the required elevation are simple and reasonable in cost, especially if only a small amount of concrete is to be handled. Wheelbarrows of 2 cubic feet capacity are used, the larger concrete buggies being too heavy. In order to cut down the slope, runways are often built with one or two returns. On some very small jobs where only a

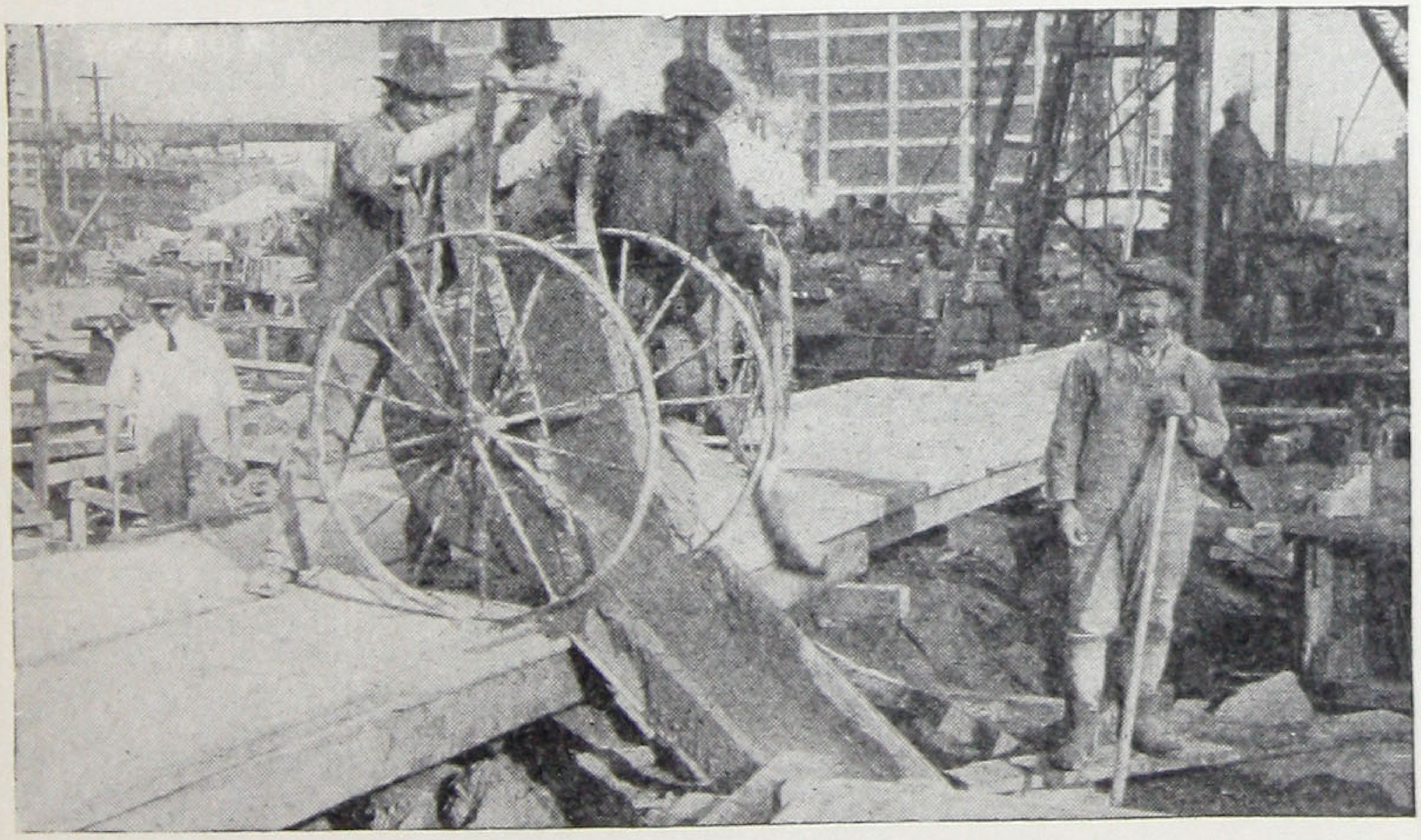


Fig. 9.—Concrete carriage or "buggy" of 6 cubic feet capacity; much superior to ordinary barrow for handling concrete.

few yards are raised a few feet, it pays to use ordinary hand pails to pass up the concrete.

For the majority of jobs a hoist of some sort will be needed. A standard concreting hoist tower is shown in Fig. 10. This is made of wood by carpenters on the job and can be used over and over again, if well cared for. A chute for discharging from the mixer into the bucket is shown in Fig. 11. Such a tower may be used not only for hoisting concrete, but by replacing the concrete bucket with a platform, may be used for elevating other materials as well.

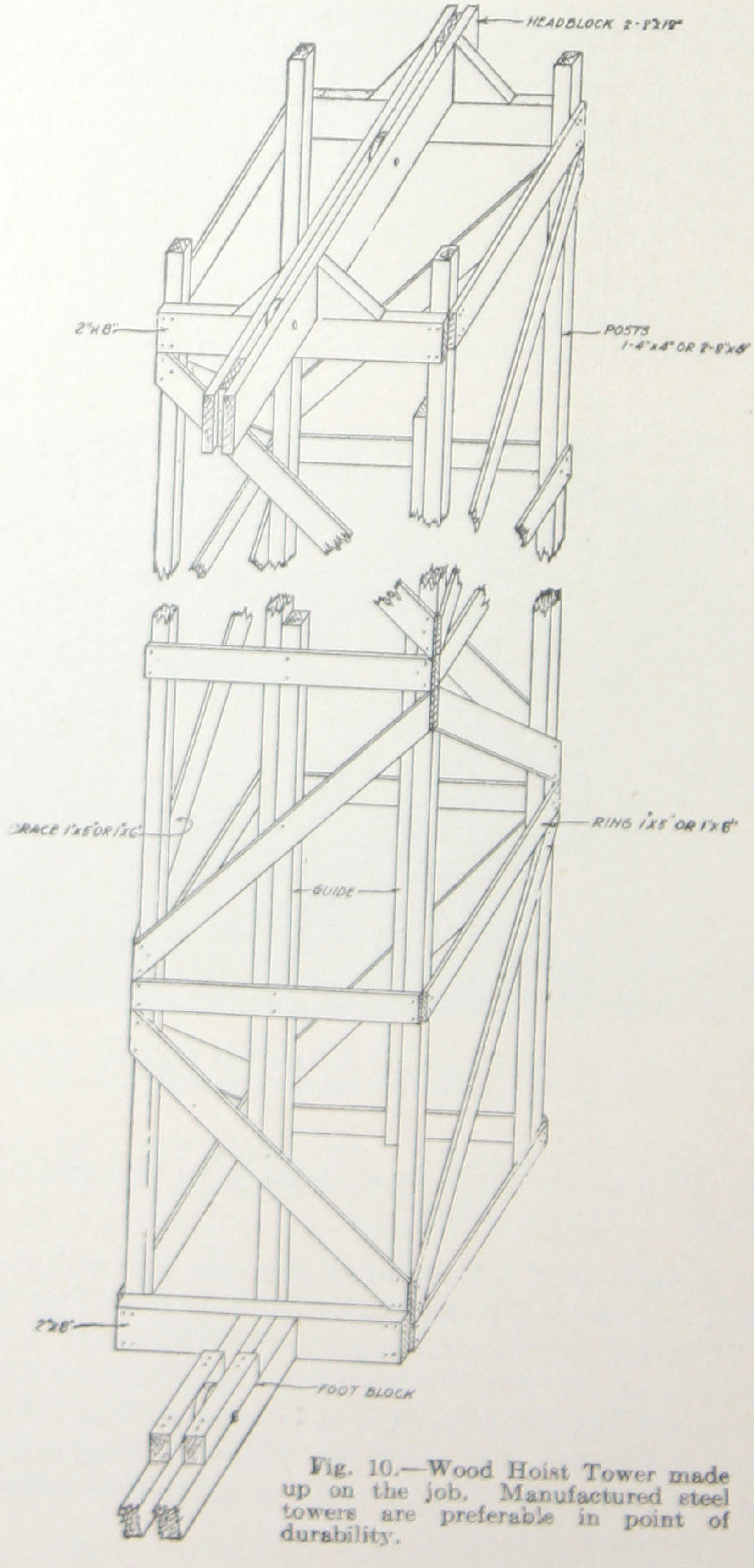



Fig. 10.—Wood Hoist Tower made up on the job. Manufactured steel towers are preferable in point of durability.

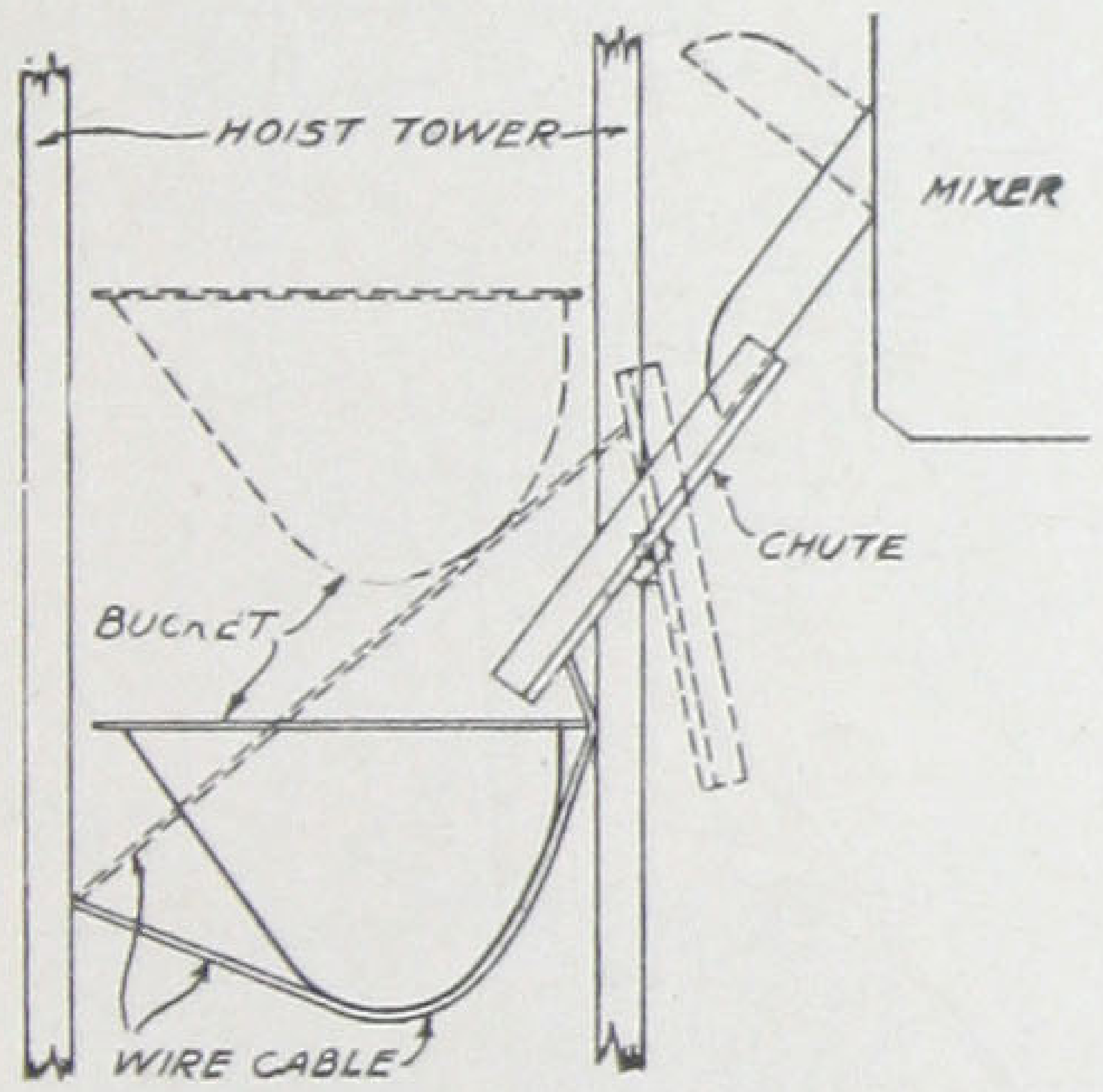



Fig. 11.—Automatic chute for discharging mixer into hoist bucket. When bucket descends it strikes the rope pulling the chute into discharging position. When bucket ascends it pushes the chute back out of the way.

Some contractors prefer to eliminate the concrete bucket by using a platform hoist for elevating the barrows one at a time. This is simple and less expensive as it requires no outlay for a bucket, but is not good policy where it is expected to keep the mixer running constantly at capacity, since the concrete could not be taken away fast enough. Fig. 12 shows a platform hoist.

A simpler rig for use where only small quantities are to be elevated one or two stories is shown in Fig. 13. This consists of a light mast which serves to guide a small bucket. Stops catch the lip of the bucket and tip it, thus discharging its contents into a hopper and chute.

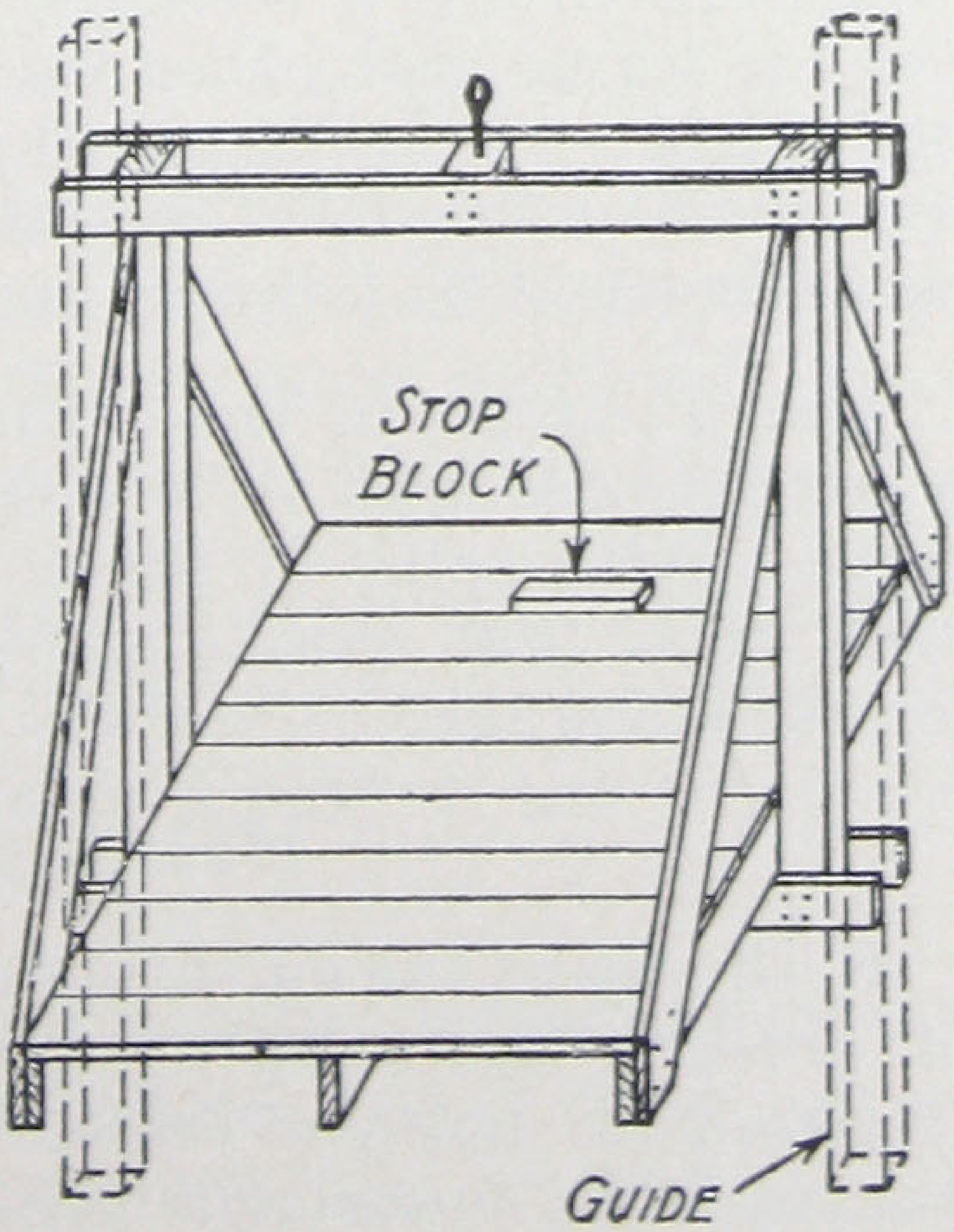



Fig. 12.—Platform hoist for wheelbarrow or loose material.

A device sometimes used for hoisting small quantities of concrete only one or two stories, as well as other material, is the jib-crane (Fig. 15). This is very useful when equipped with a small tip-bucket, or an improvised bucket made of a

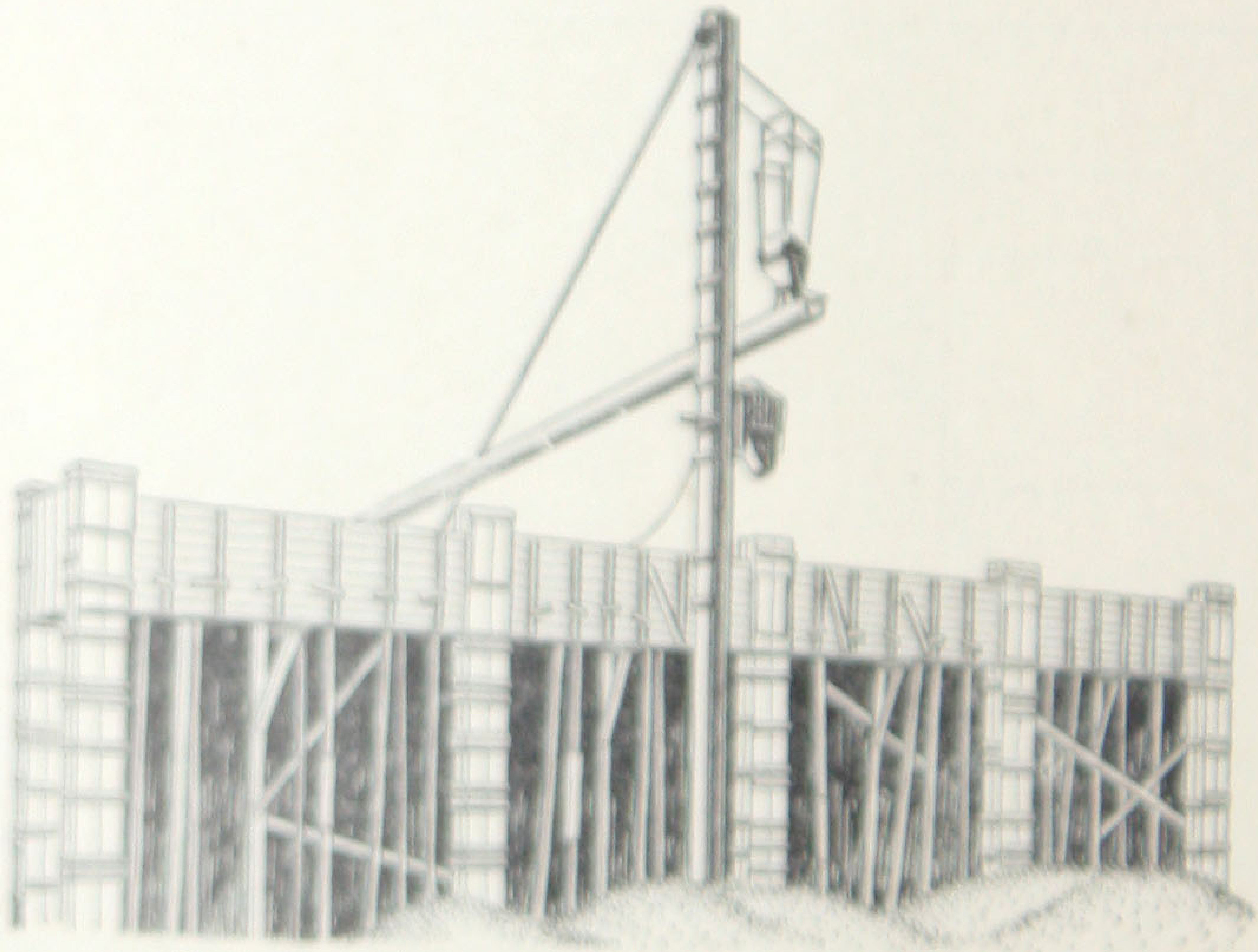


Fig. 13.—A mast hoist equipped with small bucket for elevating concrete. Bucket is tipped automatically by a stop and discharges into a hopper and chute.

large can or small steel barrel. Since the bucket can be unhooked in a few seconds, bundles of reinforcing bars, lumber for forms and other such materials can be sent up with little delay to the concreting gang. Do not try to send up too much concrete at a time with this—at the most 3 or 4 cubic feet will be a large enough load to send up safely.

The jib-crane in the form described, or a variation of it, is extensively used in silo construction, for hoisting the concrete. With some of the commercial steel forms the central steel mast that supports the forms also serves as the mast for the jib-crane.

## Hoisting Machinery

With any of the elevating equipment described, some means of hoisting must be applied. For the regulation tower a single drum hoist is needed of sufficient power to take the bucket fully loaded quickly to the tower-top. Many mixers are provided with a friction-drum and sufficient extra power to operate it.

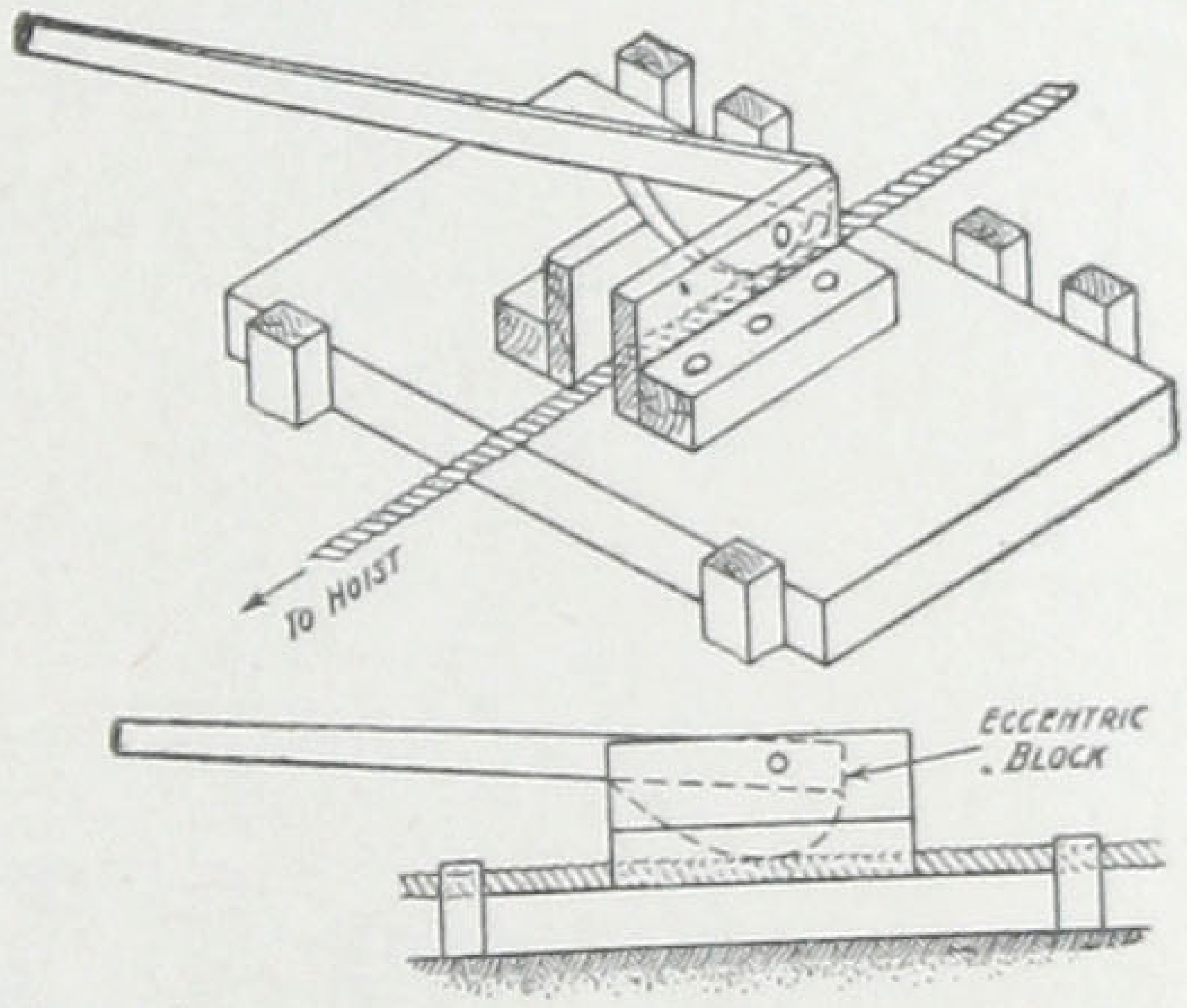



Fig. 14.—A hand-brake for use with mast hoist. The brake can be employed for controlling the descent of the bucket when a horse is employed for raising it.

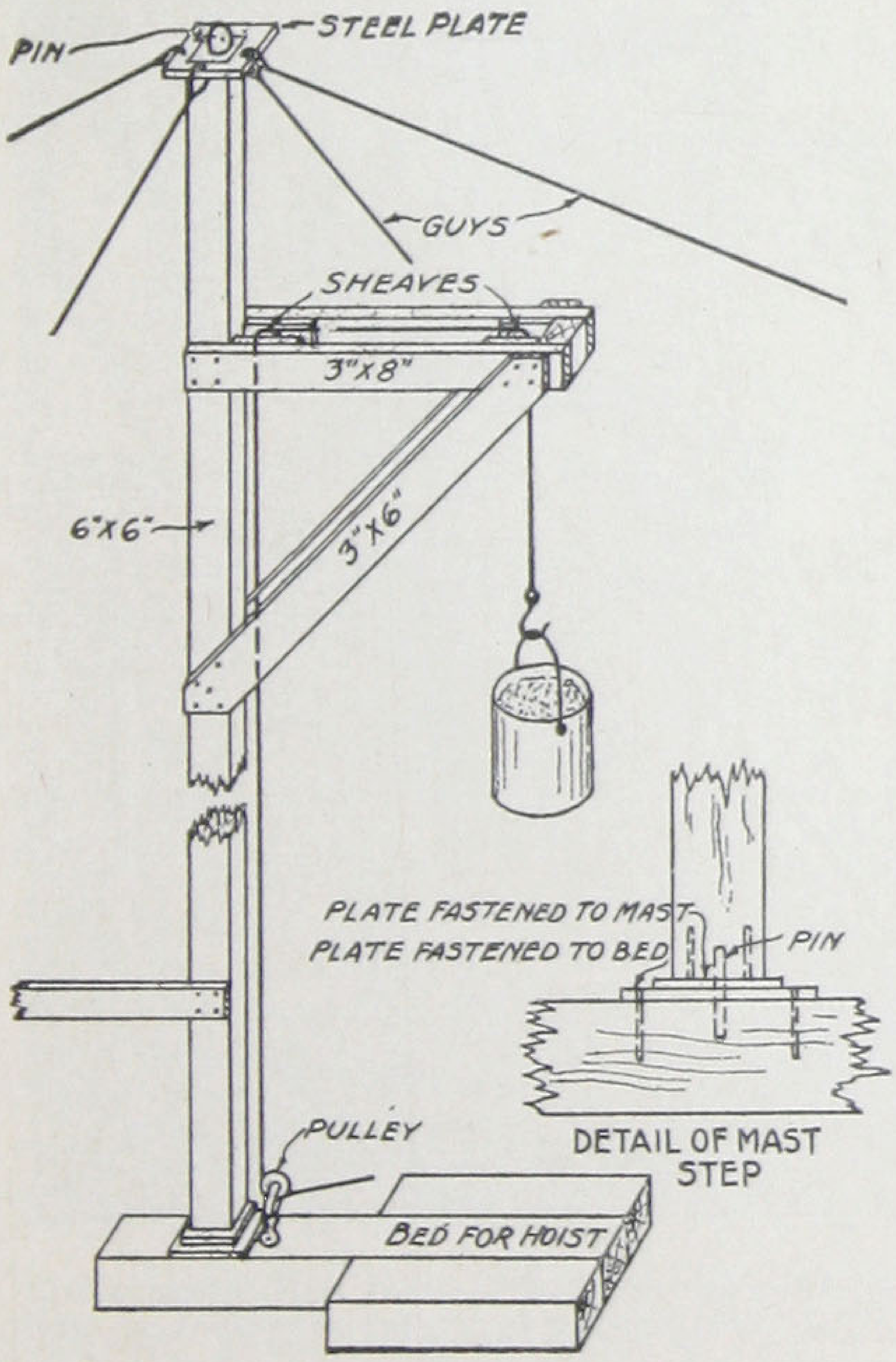



Fig. 15.—Mast-hoist or jib-crane used for lifting a very light load or a very small quantity of concrete. By making mast-step as shown in detail, this mast may be revolved.

Since these drums are generally furnished with the smaller gasoline mixers, it should be borne in mind that they are not designed for very heavy loads. If the work requires a lift of three stories or more, it is best to have a separate hoist.

There are a number of simple and reliable single-drum gasoline hoists on the market. These are ideal for small and medium sized jobs and should form a part of the equipment of every contractor.

Many jobs, such as silos, small elevated water tanks, etc., call for so small a quantity of concrete that it does not pay to bring a power hoist to the work. The combination of a jib crane (Fig. 15) and a horse will solve the problem. No more than 3 cubic feet of concrete (450 pounds) should be sent

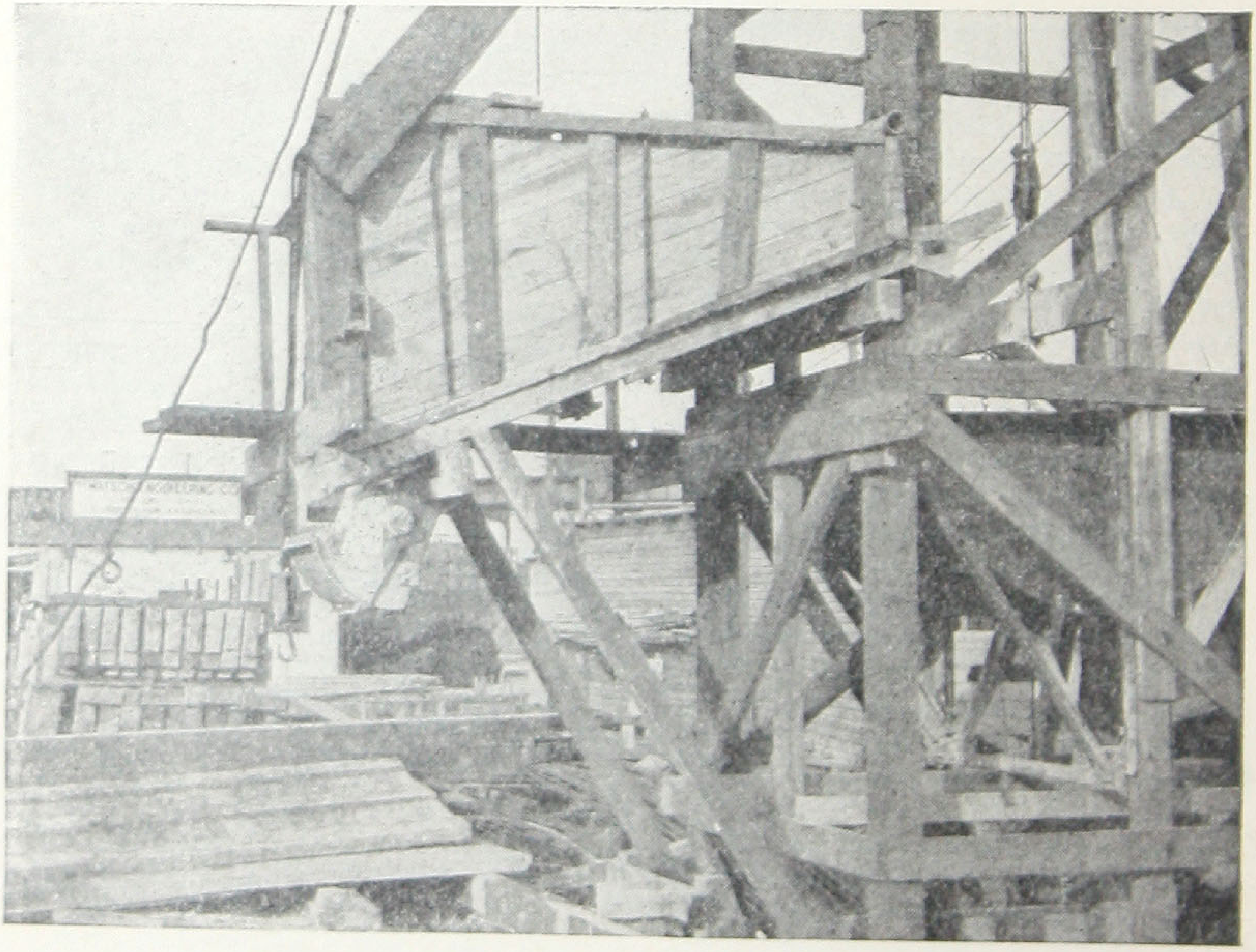


Fig. 16.—Wood hopper made on the job for use with the wood concreting tower shown in Figure 10. Usually a manufactured steel hopper is more convenient as well as much more durable.

up at one time. It is advisable to have some form of brake, such as shown in Fig. 14 to control the descent of the bucket.

When a concreting tower and tip-bucket are employed, an elevated discharge hopper must be provided as shown in Fig. 16. This hopper is made on the job, but there are on the market steel hoppers which may be used in the same way.

From this hopper, or from the bucket if one of the simpler devices is used, the concrete is discharged into wheelbarrows or concreting carts for transporting to the point of placing. For the larger jobs a system of steel chutes often is used, but this would not pay on a small or medium sized job.

## WATER-TIGHT CONCRETE

The methods employed in making concrete water-tight may be classified as follows:

(1) Accurately grading and proportioning the materials so as to secure maximum density; and depositing so as to avoid seams or porous spots.

(2) Special treatment of the surface after the concrete has hardened;

(3) Mixing compounds with the concrete—known as the integral method;

(4) Application of layers of waterproof material such as asphalt and felt to the concrete, known as the membrane system.

### 1. Accurate Grading and Proportioning of Materials

It is an established fact that an impermeable concrete can be made by the use of good, clean, well-graded aggregate so proportioned with the cement as to secure maximum density. Following is a quotation from Technologic Paper No. 3, by the Bureau of Standards, Department of Commerce and Labor, Washington, D. C.:

> "Portland cement mortar and concrete can be made practically water-tight or impermeable (as defined above) to any hydrostatic head up to 40 feet without the use of any of the so-called "integral" waterproofing materials; but, in order to obtain such impermeable mortar or concrete considerable care should be exercised in selecting good materials as aggregates, and proportioning them in such a manner as to obtain a dense mixture. The consistency of the mixture should be wet enough so that it can be puddled, the particles flowing into position without tamping. The mixture should be well spaded against the forms when placed, so as to avoid the formation of pockets.
>
> "The addition of so-called 'integral' waterproofing compounds will not compensate for lean mixtures, nor for poor materials, nor for poor workmanship in the fabrication of the concrete. Since in practice the inert

integral compounds (acting simply as void filling material) are added in such small quantities, they have very little or no effect on the permeability of the concrete. If the same care be taken in making the concrete impermeable without the addition of the waterproofing materials as is ordinarily taken when waterproofing materials are added, an impermeable concrete can be obtained."

No matter how impermeable the concrete may be made, it will be to little purpose if the placing of concrete is done in a careless manner so as to permit the occurrence of seams, cracks, poorly made construction joints, air or stone pockets, and porous spots which later allow the water to leak through. If the difficulties of placing the concrete are such that such defects cannot be guarded against with certainty, it is best to adopt the waterproofing methods of surface treatment or membrane system described later. It is obvious that integral waterproofings also are of little help in preventing leakage through the defects listed above.

## 2. Special Treatment of Surface

The second method involves the treatment of the surface, dealing with the use of a cement mortar or wash of some kind, applied to the surface of the concrete after the removal of the forms. The concrete is first cleaned and roughened so as to insure a proper bond. All dirt or grease must be removed as the presence of these substances on the concrete prevents the adhesion of the mortar. A stone pick or similar tool should be used to roughen the surface thoroughly, then the concrete drenched with water, and the mortar applied to a thickness of ⅝ to 1 inch. This is generally done in two coats applied at intervals of 24 hours. The first is a scratch coat which should be thoroughly roughened with a stick or trowel before it has set, and the second coat is applied and brought to a smooth finish with a trowel. A good mixture is one part Atlas Cement, two parts clean, coarse well-graded sand, and one-tenth part hydrated lime.

A successful method for securing a dense impervious surface for such work as water tanks, cisterns and well linings, is the application of ordinary paraffin to the inside surface of concrete, after it has hardened. The surface should be thor-

oughly clean and perfectly dry. Hot paraffin is brushed on and then driven into the pores of the concrete with the flame of a gasoline blow-torch. The paraffin penetrates the surface. Greatest penetration is secured when the concrete is warm, as in the summer time.

A cold application consisting of dissolved paraffin or other wax is also efficacious. The solvent carries the wax into the pores of the surface concrete and then evaporates leaving the wax in the pores and on the surface. The Bureau of Standards found this type of waterproofing the most effective in its tests on colorless waterproofing treatments. The treatment changes the color of the concrete very little.

### 3. Integral Method

The third method involves the mixing of some material with the concrete, which acts as a void filling substance. Hydrated lime is being used successfully for this purpose. The addition of ten per cent of hydrated lime based on the volume of the cement, makes the concrete denser and more watertight, and this amount does not cause any appreciable loss in the strength of the concrete. Instead of the hydrated lime, many contractors figure that the use of additional cement in the mix is the most economical and satisfactory way of securing watertight concrete. Just add 10% to 20% extra cement, depending on the water pressure. There are integral waterproofing compounds marketed by different manufacturers which are also used for the purpose of rendering concrete waterproof.

### 4. Membrane System

The membrane system of waterproofing is the coating of the surface of the concrete with an asphaltic or other coat which is of itself waterproof. This can usually be done on only the side of the wall from which the water pressure comes. (See Fig. 18.)

Two coats of hot asphalt or coal tar thoroughly swabbed on the wall are commonly used. Bituminous brush coatings can be obtained which can be applied cold without melting or

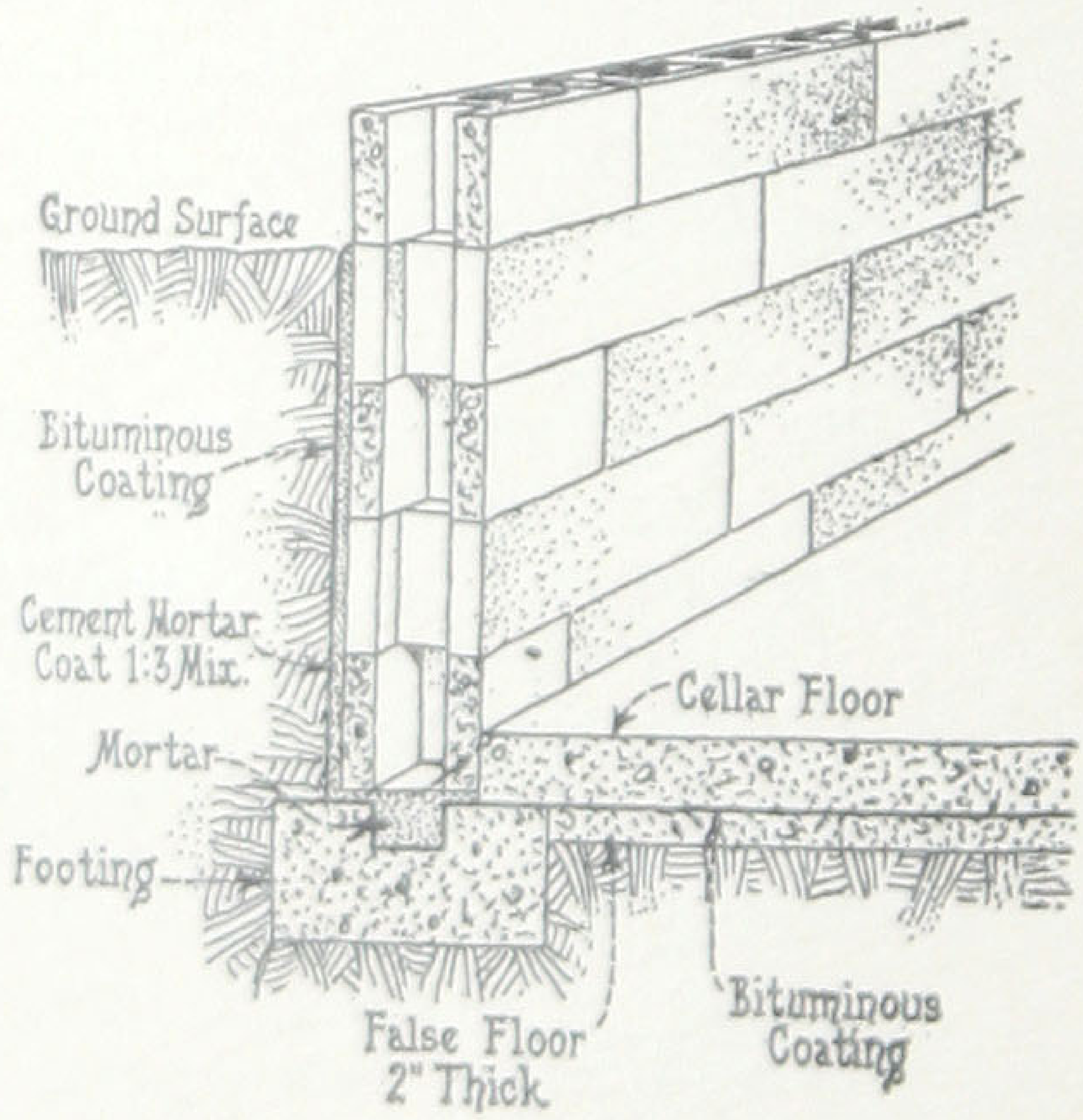


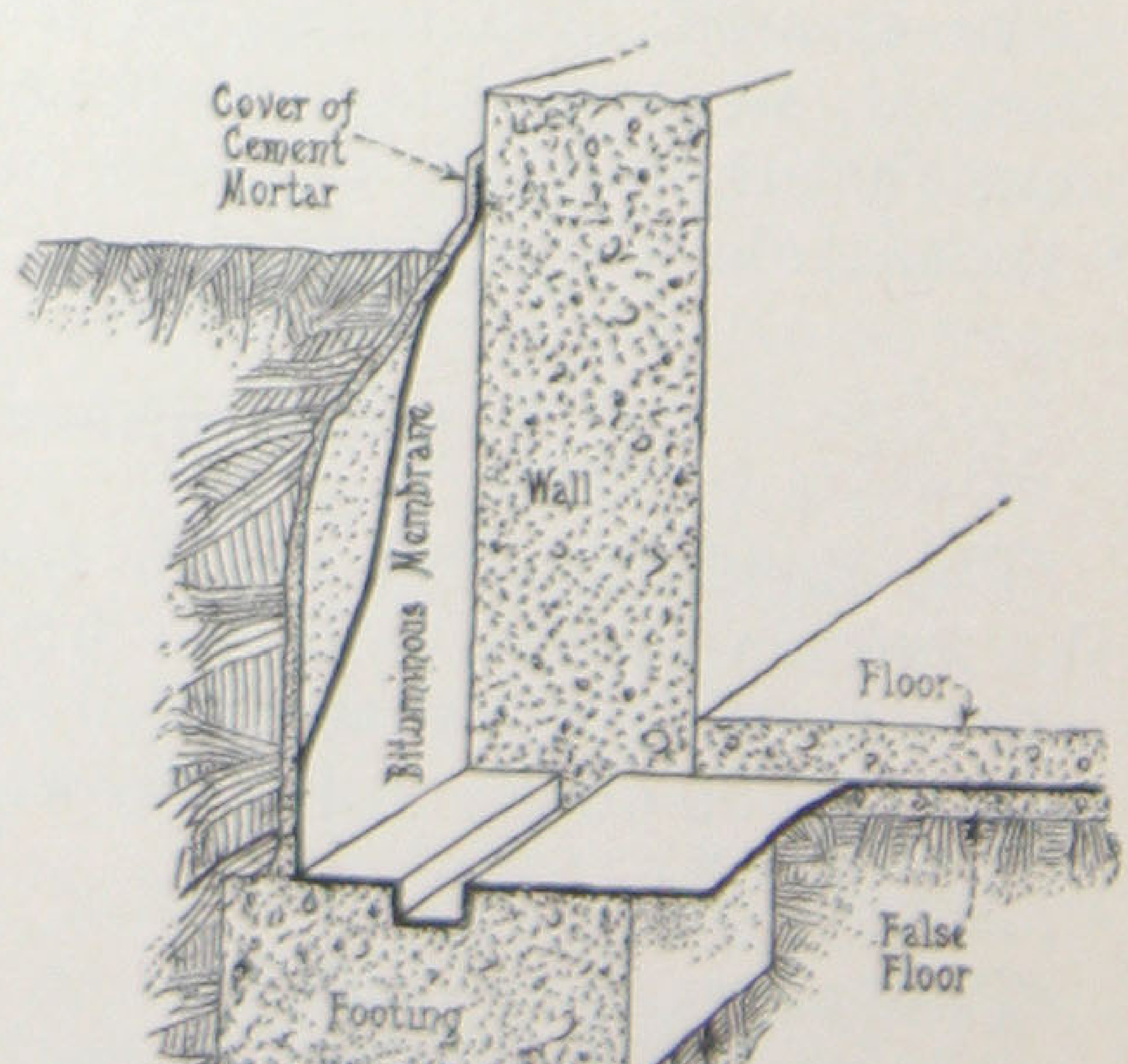

Fig. 17.—One method of rendering a concrete cellar wall water-tight. If the ground is wet it is best to rely on some form of surface coating or membrane, because it is difficult to avoid joints, seams or porous places in concrete deposited below ground level.

heating. For very particular work, successive layers of hot asphalt and felt or burlap are used.

If you have any problem in waterproofing either in structures already built or to be built, the Atlas Portland Cement Company will be glad to cooperate in choosing the method of securing best results.

Fig. 18.—An example of bituminous membrane water-proofing as used for a cellar wall. If properly executed, this type of waterproofing is most certain of results.

This method is usually employed only when conditions are unusually severe.



## CONCRETING IN COLD WEATHER

Concrete work can be done successfully, in cold weather by observing a few simple rules. In making and placing concrete with the temperature below 35 degrees Fahrenheit, keep the concrete from freezing until it has become thoroughly hardened. Freezing is prevented by (1) Heating the materials, (2) protecting the fresh concrete from the cold.

Water for mixing may be heated in the water barrel, or supply tank, by a coil of pipe through which passes exhaust or live steam. There are also devices for heating the water by direct contact with steam as it passes through a mixing valve. On small jobs a large kettle or caldron with fire beneath is employed. Water is usually heated to about 150 degrees.

One method of heating the sand and stone is by embedding a discarded sheet iron pipe in the piles (Fig. 19). A wood fire in the pipe furnishes the heat. Sand and stone are sometimes heated by steam coils or by thrusting one or more steam pipes into piles of material. The steam pipes are drawn down to a small opening at the end so as not to pass too much steam. Some prefer to perforate the steam coils with a number of small

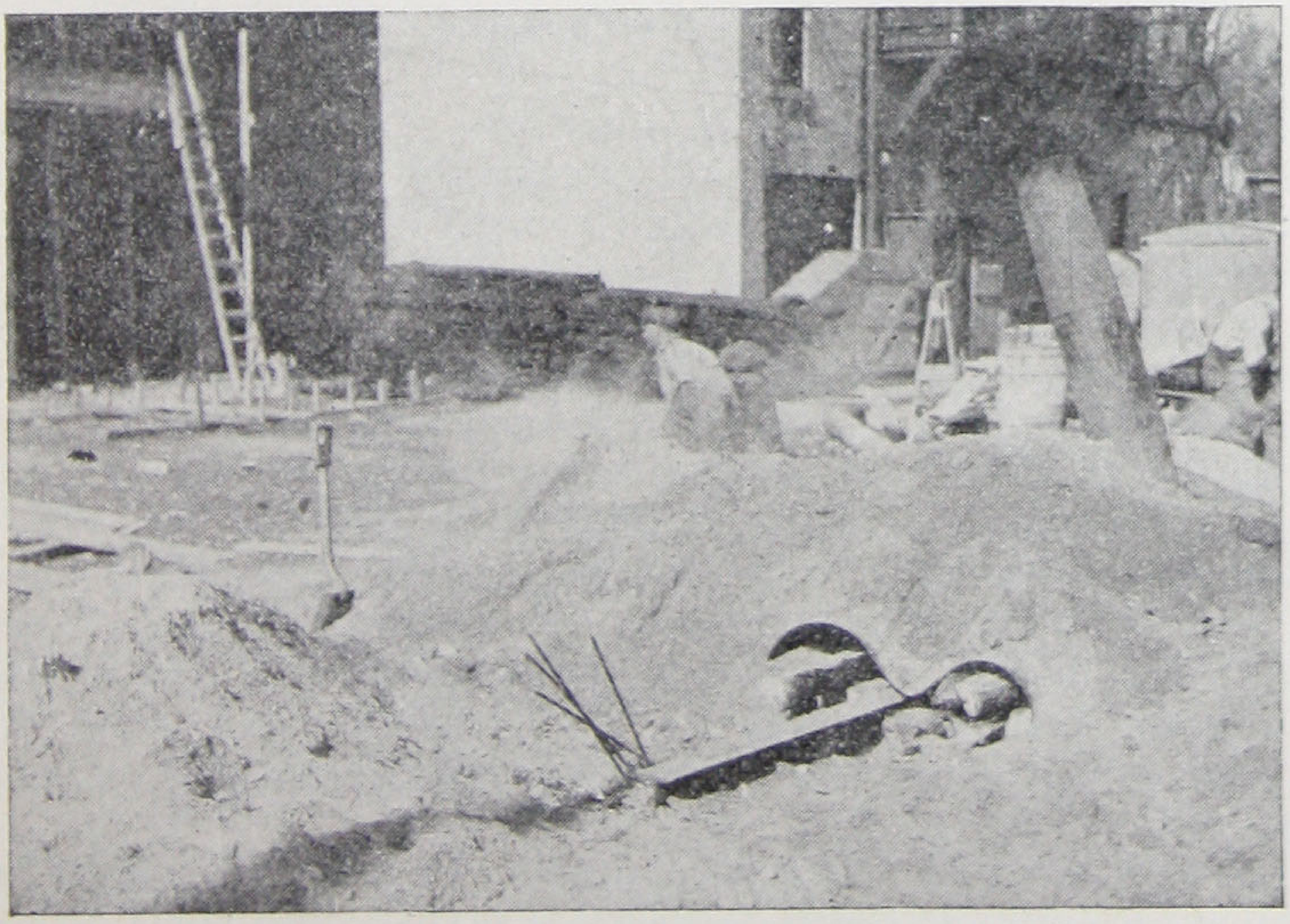


Fig. 19.—A simple way of heating sand and stone by means of sheet iron pipes with fire inside.

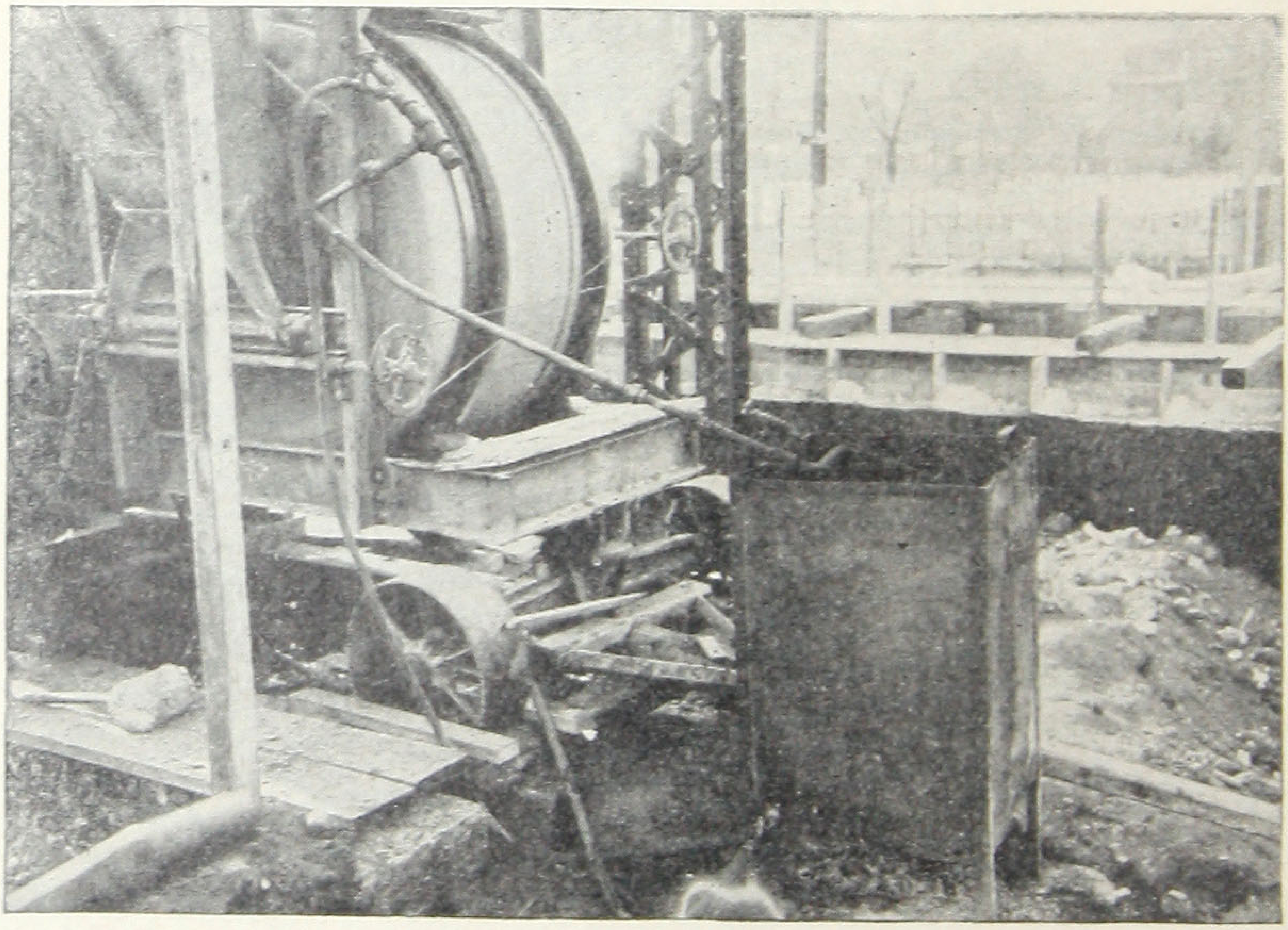


Fig. 20.—Heating mixing water by means of a steam coil at the mixer. Steam jets, steam mixing valves, and other devices are also employed for heating mixing water. For very small jobs a tank or caldron with fire beneath will be sufficient.

holes to allow the steam to pass out. As the steam rises through the sand and stone it effectually heats the particles. Canvas may be stretched over the tops of the material piles to prevent the too rapid escape of the steam.

All fresh concrete must be protected immediately upon being placed in the forms. This suffices for large masswork or where temperatures are not very low; canvas and a thick layer of hay or straw should be used as a covering. For small concrete members or thin floors where the mass of concrete is small, it is customary to enclose the work with building paper or canvas and heat the interior by means of "salamanders" (sheet iron stoves). It is now the usual practice to enclose reinforced concrete buildings with canvas and keep the interior temperature well above freezing by the use of salamanders.

For winter work forms must be left in place a longer time than with summer temperatures. Further details on winter work may be obtained by sending for "Concreting in Winter"

## CONCRETING UNDER WATER

To obtain good concrete, when it must be placed under water, it is necessary to get the concrete in place without giving the water a chance to separate the aggregates and cement.

The simplest and probably best method is to use a "tremie" (Fig. 21). This is a sheet iron cylindrical chute with a hopper at the top. It is open at both ends. The cylindrical portion should be large enough to hold an entire batch of concrete and long enough to extend from just above the water level to the bottom of the excavation to be concreted. The "tremie" is placed in the water and filled with concrete. It is then raised slowly just far enough to allow part of the concrete to escape through the open bottom and spread into place. The lower end of the pipe should never be emptied of concrete. This will prevent the entrace of water from the bottom.

When only a very small amount of concrete is to be placed, it can be shoveled into a length of stove pipe used in much the same manner as a "tremie." This is simply and easily

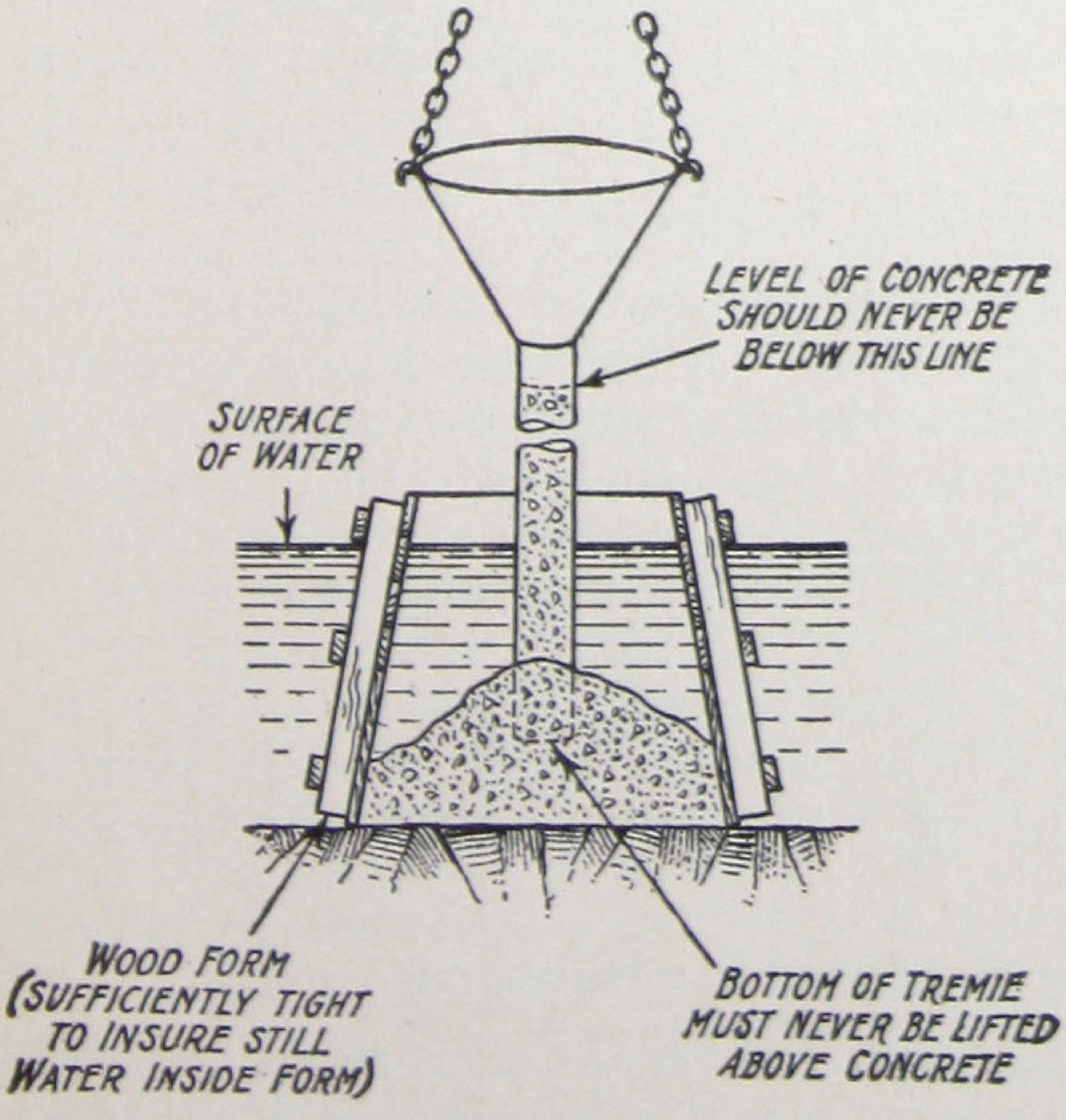



Fig. 21.—Depositing concrete under water by means of a pipe or "tremie." Details of this illustration need not be followed exactly but can be adapted to each particular class of work.

done. First put the pipe in position and fill it full of concrete to expel the water. Then gradually lift it a little each time you put in a batch.

Just as small an amount of mixing water as is possible should be used for all concrete placed under water so as to reduce the danger of separation of the concrete materials.

Concrete under water has a greater tendency to form a scum or laitance than concrete above water. For this reason a mass of concrete under water should be poured in one operation, though it may require both day and night work. Otherwise, there will be laitance seams which will greatly reduce its strength. Walls that are partially under water should have the wall brought above the water level before the concreting is stopped. Provision can then be made for building the rest of the wall at a later date by placing bonding bars or stones in the top of the wall, care being taken to remove the laitance.

## BONDING CONCRETE OR MORTAR TO CONCRETE ALREADY IN PLACE

The bonding of concrete surfaces is divided into two classes: finishes on vertical surfaces, such as stucco work and cement mortar plastering,—and horizontal surfaces such as floors, sidewalks and joints in walls.

### Vertical Surfaces

If the forms are removed as soon as the concrete can bear its own weight, the surface film can be removed by brushing with a heavy wire brush. Better results can be sometimes obtained by using a sharp pointed tool. If the forms have been greased, the walls should be washed down thoroughly with a solution of one part muriatic acid and four parts of water. Then all trace of the acid must be removed by thorough washing. When the mortar coating is to be put on, thoroughly drench the wall with water, and before the mortar is applied, brush the surface with a creamy mixture of cement and water.

### Preparing Surfaces for Bonding

In place of roughening surfaces by acid washing and mechanical methods, there has been recently introduced a chemical

method for securing the same results. An insoluble chemical solution is painted on the forms before concrete is poured and renders the surface film of concrete "dead" so that it can be brushed off or washed off very easily, leaving the aggregate exposed and the surface rough and in excellent condition for furnishing a good bond. Name of manufacturer of this material will be furnished upon request.

### Horizontal Surfaces

Bonding horizontal surfaces usually consists of placing the finishing coat on floors or sidewalks, or pouring concrete for walls on successive days.

If the concrete has hardened, the surface must be thoroughly cleaned, roughened and wetted. Then apply a creamy mixture of cement and water by the methods already described and follow immediately with the topping if a floor or sidewalk, or additional concrete if a wall.

## CURING CONCRETE

If the forms are allowed to stay in place for several days they will provide sufficient protection. If they are removed while the concrete is still green, protection should be provided by covering with canvas or burlap, or sprinkling, which will prevent drying too rapidly. Too rapid drying out is liable to cause cracks and a weakened concrete. The presence of sufficient moisture during the early hardening period of ten days or two weeks will greatly increase the strength of the concrete.

Floors, sidewalks, driveways and similar work having large areas of exposed surfaces require special protection to prevent too rapid drying out. As an illustration concrete road specifications require that the concrete be first protected by covering with canvas and then as soon as there is no danger of pitting, that the concrete be covered with dirt and kept wet for a period of ten days. Such specifications strongly emphasize the importance of proper curing of concrete because it is realized that the strength and resistance to wear depend so greatly upon this.

## SURFACE FINISHES

A good surface finish adds to the attractiveness and hence to the value of the structure. There are several different finishes for concrete.

For ordinary construction a smooth, dense surface, free from cavities is sufficient. Cavities can be prevented by spading and churning the concrete as it is poured and by pounding the forms with wooden mallets to force back the coarse aggregate from, and bring the mortar to, the surface of the form. (Fig. 22.)

The washed or scrubbed finish is attractive and easily handled. It is obtained on the spaded or mortar faced surface, by using a stiff fibre or wire brush with plenty of water while the concrete is still green. The forms must be removed in about twenty-four hours in order that the surface may be effectively treated. If too green, the aggregate will break out and if allowed to harden too long the work cannot be done effectively. The washing of the surface should be continued until a uniform texture results.

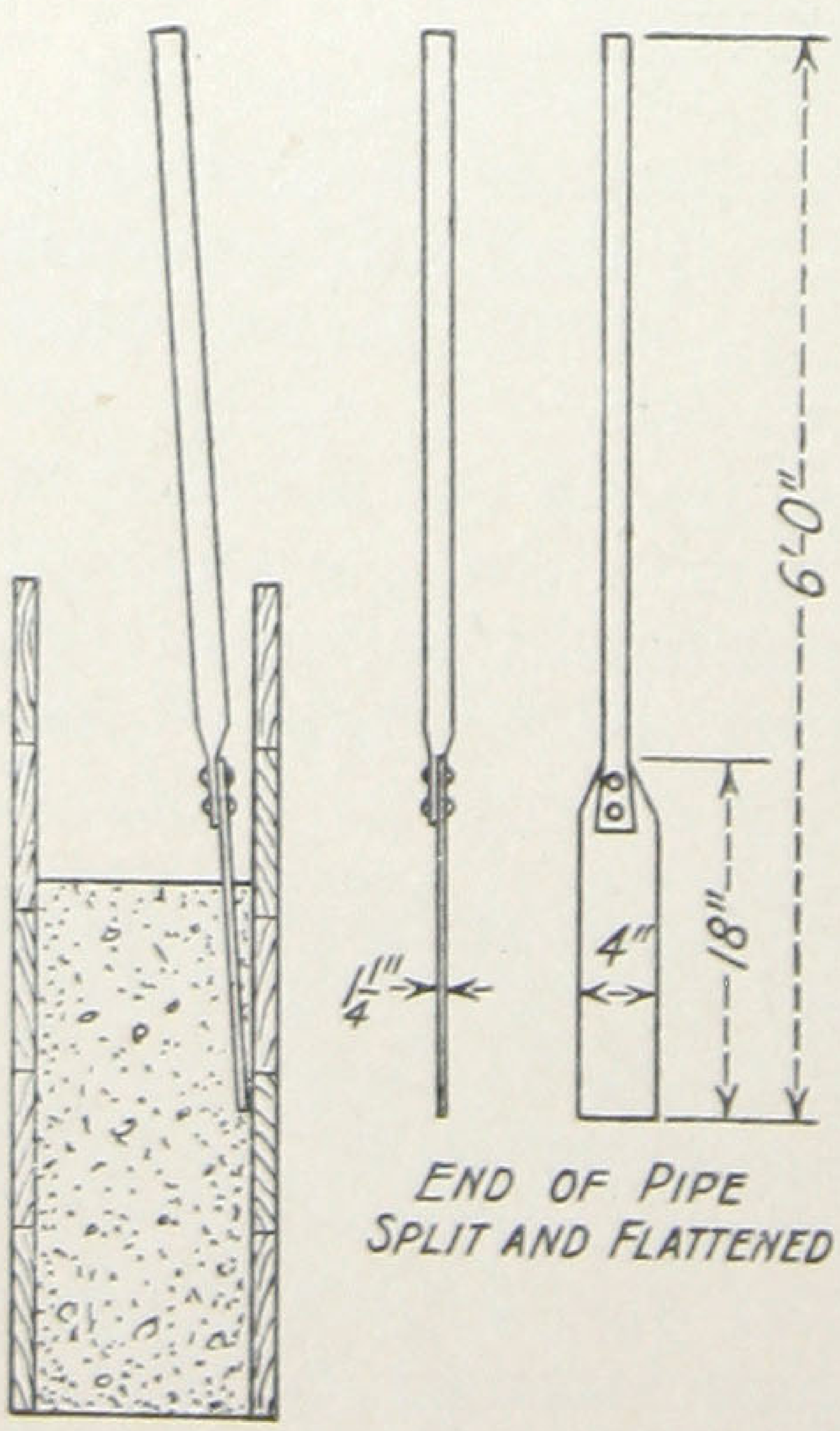
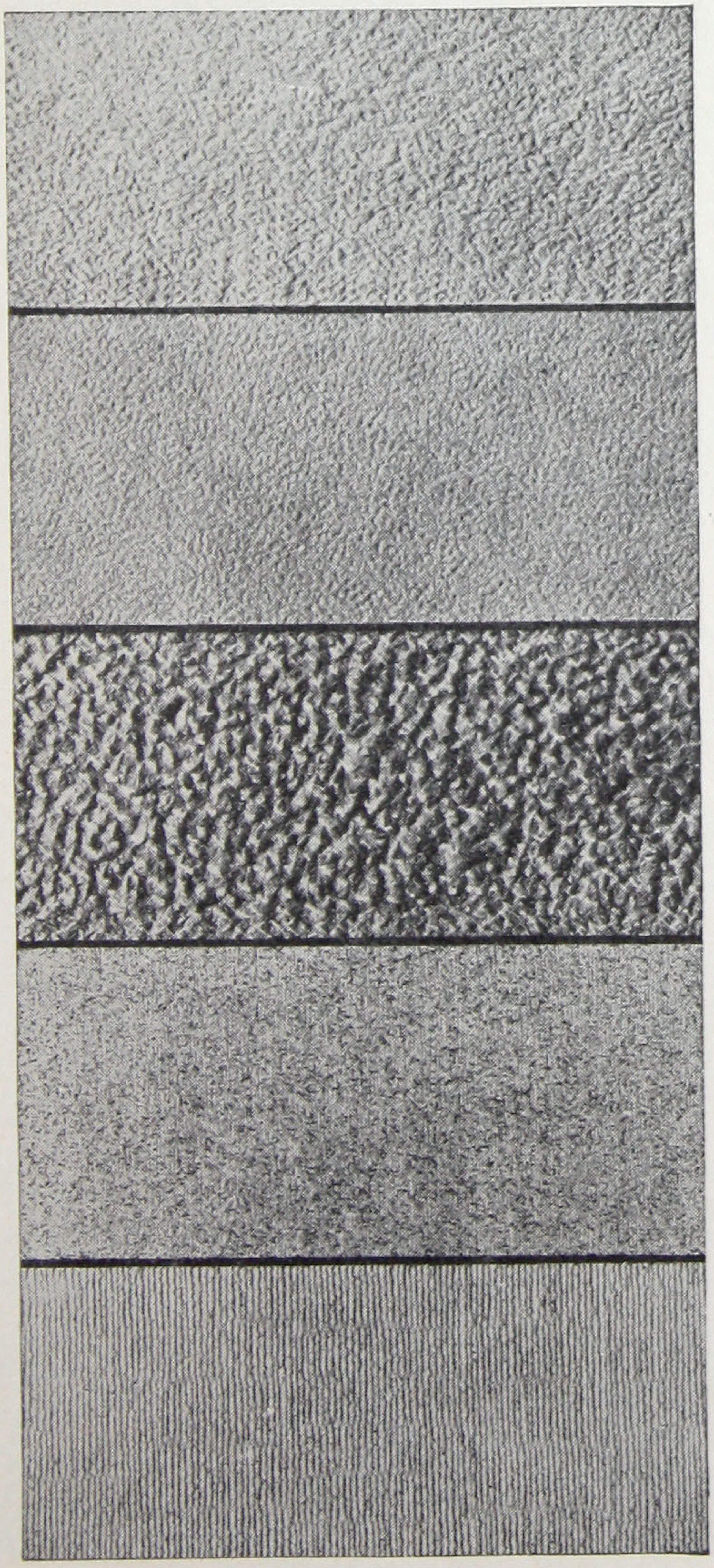



Fig. 22.—Spading tool for securing good surface next to the form. A thin board may be used if the spading tool is not available.

Exposing the aggregates by chemical means is now being done by a recently introduced method. The process is the same as described in the paragraph headed "Preparing Surfaces for Bonding" (see page 35 and Fig. 24).

The rubbed surface is much used and very satisfactory. By spading the concrete as above described and pounding the forms with a wooden mallet an even surface next to the forms is secured. While the concrete is still soft and moist—(rubbing should be done within 24 hours after pouring if forms can be removed)—rub this surface with a wooden float on which is placed from time to time coarse sand and water, or use a carborundum brick dipped in water. If



The upper three blocks are hammer finished, in fine and coarse pointed texture. The rougher finish is best adapted to concrete with large size coarse aggregate and the finer textures to cement-sand surfaces.

The two lower blocks are fine and coarse bush-hammer finish. The width of lines is determined by the thickness of the blades in the bush-hammer. Concrete which is to be bush-hammered must be thoroughly hard and made of a tough, hard coarse aggregate.

**Fig. 23—Types of Concrete Surface Finish**

there are pockets they should be filled during rubbing with a 1 : 2 mortar. If the concrete has hardened the form marks and fins left by the boards can best be removed by rubbing with a carborundum block.

Tooling may be done either by hand tools, such as picks and bush hammers, or by pneumatic or electric hammers, and very satisfactory results are obtained. The concrete should be at least thirty days old. It must be well-hardened and should be older for pneumatic hammering than for hand-tooling. (Fig. 23.)

A "dash" finish coat can be applied directly to the surface of concrete. A creamy mixture of 1:2 Atlas-White Cement and sand is thrown on with a stiff brush, so as to thoroughly cover the concrete surface. This produces a very attractive finish at small cost. The concrete surface preferably should be "green," that is not thoroughly hardened. (Fig. 25.)

Stucco when applied to concrete makes a very satisfactory surface finish. It is of utmost importance that the concrete

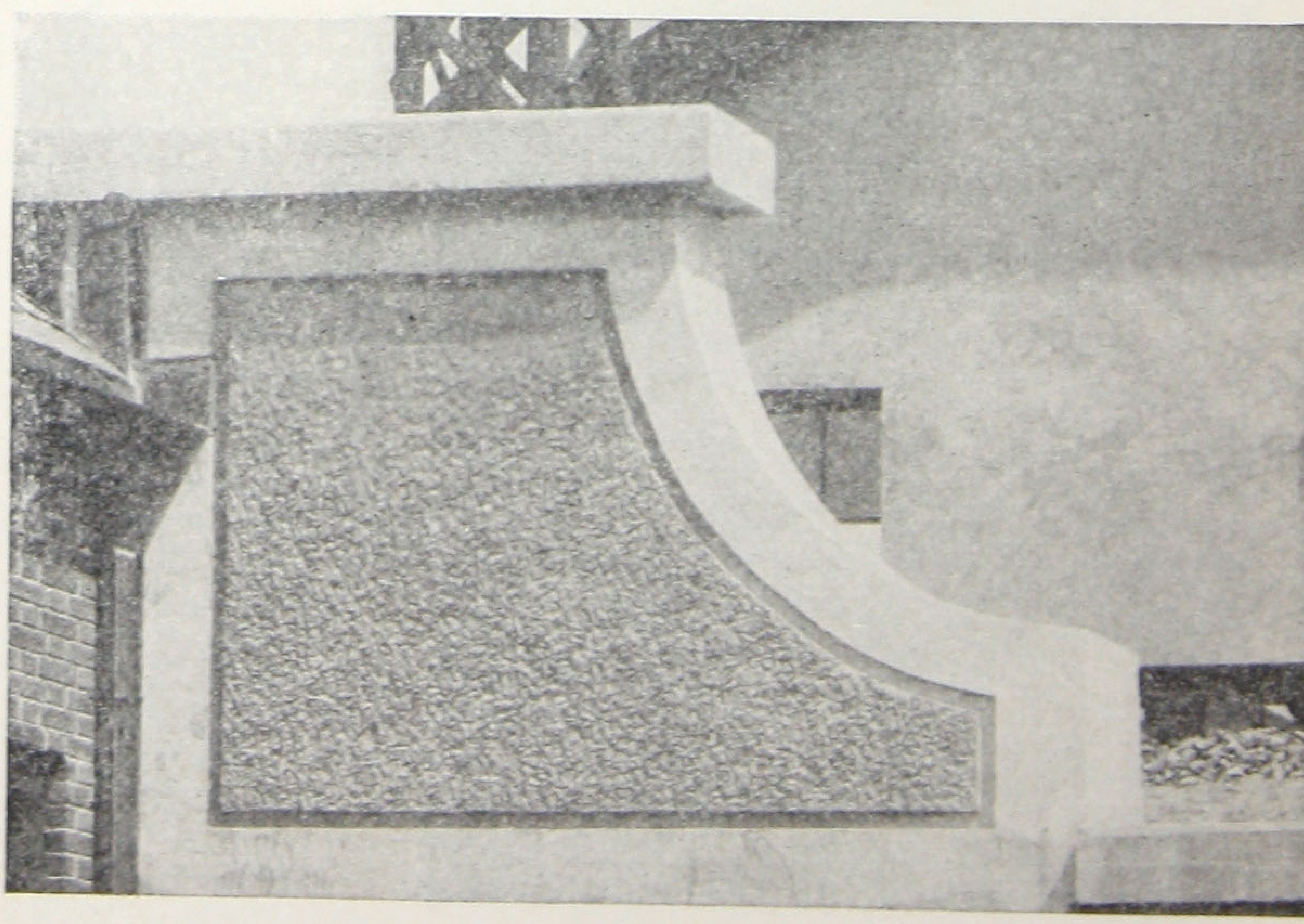


Fig. 24.—An exposed aggregate finish secured by chemical methods described on page 35. This method gives a pleasing appearance with a minimum of labor.

be properly prepared by roughening, cleaning and wetting, so that the stucco will adhere firmly. If the forms are removed within 24 hours the surface of the concrete can be treated with a wire brush, so as to remove the surface film. If it is necessary to leave the forms on for a longer time the surface can be roughened by means of a stone pick or similar tool. All loose particles should then be entirely cleaned off and the concrete should be thoroughly drenched with water. (See page 35 for chemical method of roughening surface.)

Stucco is a mixture of cement, sand and water, with or without the addition of hydrated lime; in other words, it is a cement mortar. The mixture suggested is one part cement, three parts sand and one-tenth part hydrated lime.

A large variety of surface finishes are possible, such as smooth, rough, stippled, spatter-dash and exposed aggregate. The use of Atlas-White with coloring pigments, or with color aggregates, such as colored sands, colored crushed marble or crushed granite, allows a wonderful variety of color effects. The color combinations and textures are practically unlimited.

Stucco is also applied to concrete blocks, hollow tile, brick, and metal lath. Further information on stucco with specifications will be gladly furnished by The Atlas Portland Cement Company.

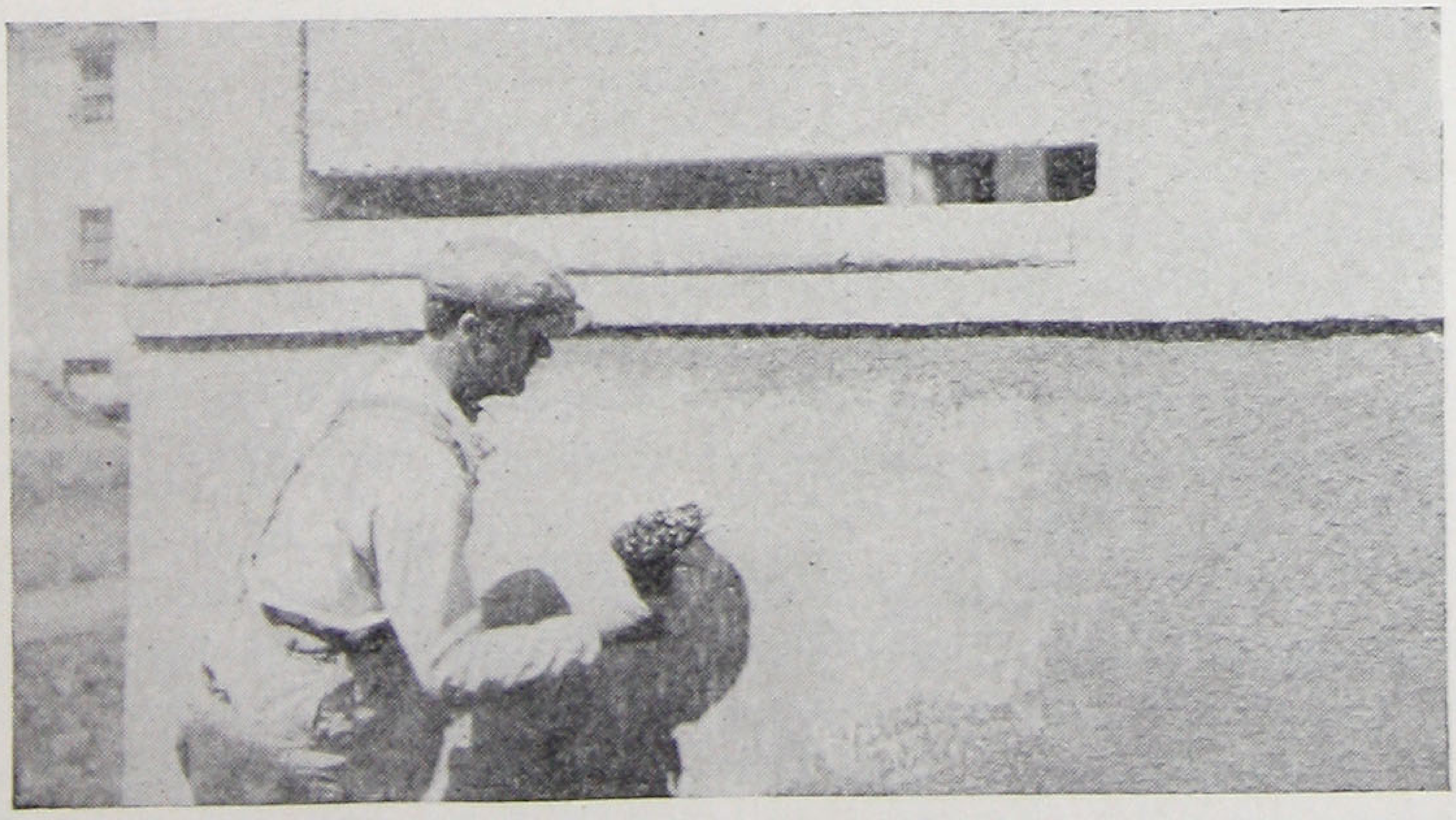


Fig. 25.—Sand-spraying or spatter-dashing a poured-concrete surface. This type of surface finish must be applied while the concrete is still "green" and before the surface has become dirty or dusty.

# CHAPTER II

# REINFORCED CONCRETE

Reinforced concrete is a combination of steel and concrete. Concrete in its qualities of strength is very similar to stone. It will stand great pressure, or compression, but is comparatively weak in resisting pull, or tension.

Because concrete is strong in compression, and steel is strong in tension, steel rods are embedded in the concrete to resist tension, and the concrete bears the compression. This is the basis of reinforced concrete. In this way each material does the work best suited for it.

## BEAMS AND GIRDERS

The principle of reinforced concrete is clearly shown in the case of a beam. If a beam is laid on two supports and a heavy load is placed on the center, the top of the beam is in compression while the bottom is in tension. If the beam were of wood, it would be very noticeable, as the wood in the top of the beam would be crumbled together, while at the bottom of the beam it would be torn apart.

The same action occurs in a concrete beam. Figure 26 shows a concrete beam broken in two by a load on the center. The point where the break first occurs is at the bottom because the concrete is weak in tension. If there had been some steel bars, which are very strong in tension, in the bottom of the beam as shown in Figure 27 the steel would have taken the tension.

Concrete is fireproof and is not harmed by water; while steel loses its strength when heated and rusts if subjected to moisture. When embedded in concrete, the steel reinforcing rods are protected from fire and water. In all reinforced concrete work, the steel rods should be covered with from one to two inches of concrete.

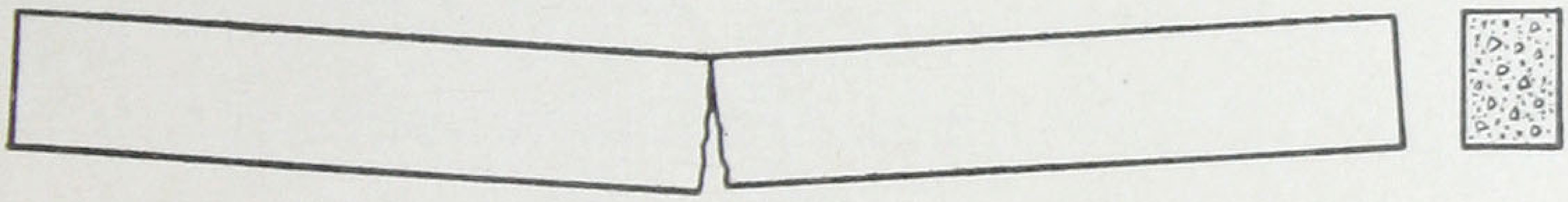


Fig. 26

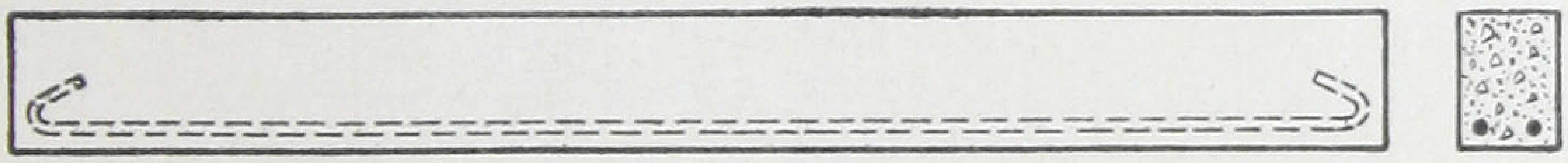


Fig. 27

When a plain concrete beam is loaded until it begins to break, it cracks in several places, as shown in Figure 29. In the center of the beam the cracks are perpendicular, while toward the ends the cracks are more and more at an angle. It is readily seen that the proper place for the reinforcing steel is at right angles to the cracks; but in practice this is impossible, as it would require such complicated placing of the steel. A compromise is therefore made.

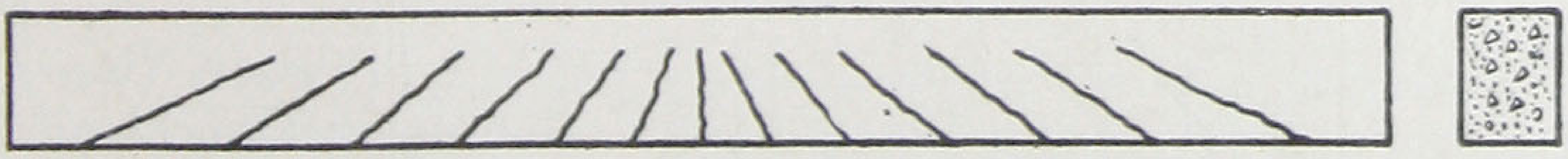


Fig. 28

## Location of Reinforcing Steel

Some of the bars are left straight for the entire length of the beam. These are at right angles to the cracks near the center, as shown in Figure 29. Then some of the bars are bent, as shown in Figure 30. These, known as doublebent bars, take care of the possible cracks toward the ends. Smaller-sized bars, in the shape of a "U," and known as stirrups placed closer together near the ends of the beams than toward the center are used to take care of additional stresses, Figure 31.

Thus, in Figures 29, 30, and 31 are shown the three types of bars for beam reinforcing; and in Figure 32 the complete reinforcing.

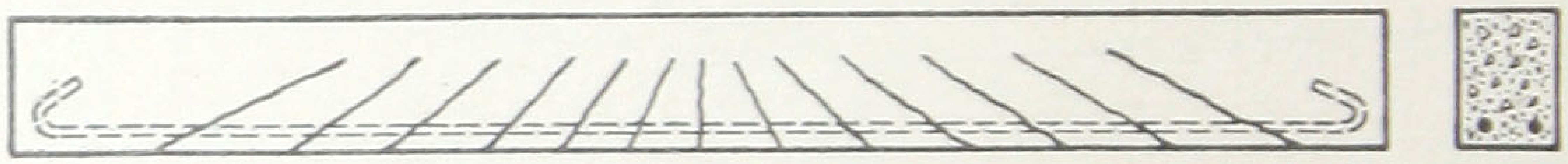


Fig. 29

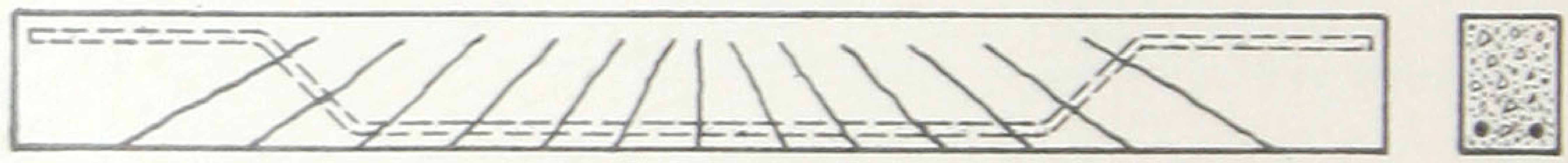


Fig. 30

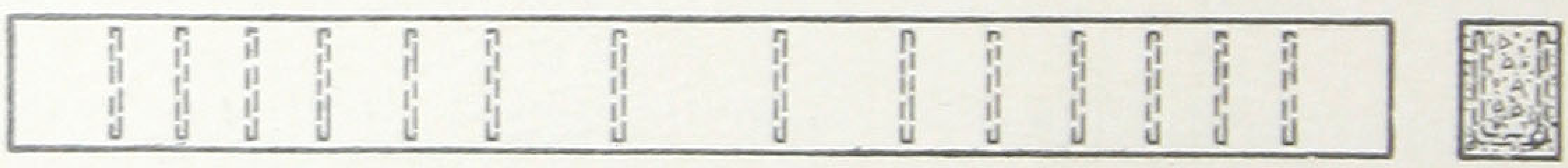


Fig. 31

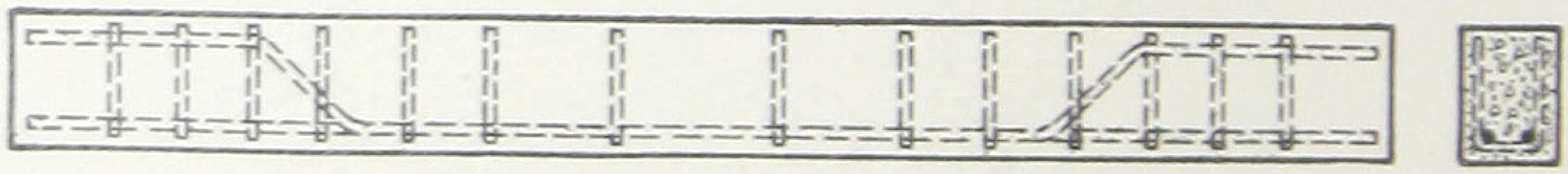


Fig. 32

## Kinds of Beams

Beams are called simple if they extend between two supports only, neither end being fixed. Beams in large building work are usually made to extend from one side of the building to the other, being supported by a number of intermediate columns. These are known as continuous beams.

Another type of beam is the cantilever, in which only one end of the beam is supported. This end must be securely held, as if in a vise.

## Loads

The loading on a beam may be uniformly distributed throughout the entire length, or concentrated in one point: or a combination of both. A beam supporting a wall of uniform weight and thickness, is an example of a uniformly loaded beam, Figure 33.

If, instead of this wall, the beam carries the load transmitted from another beam, there would be a concentrated

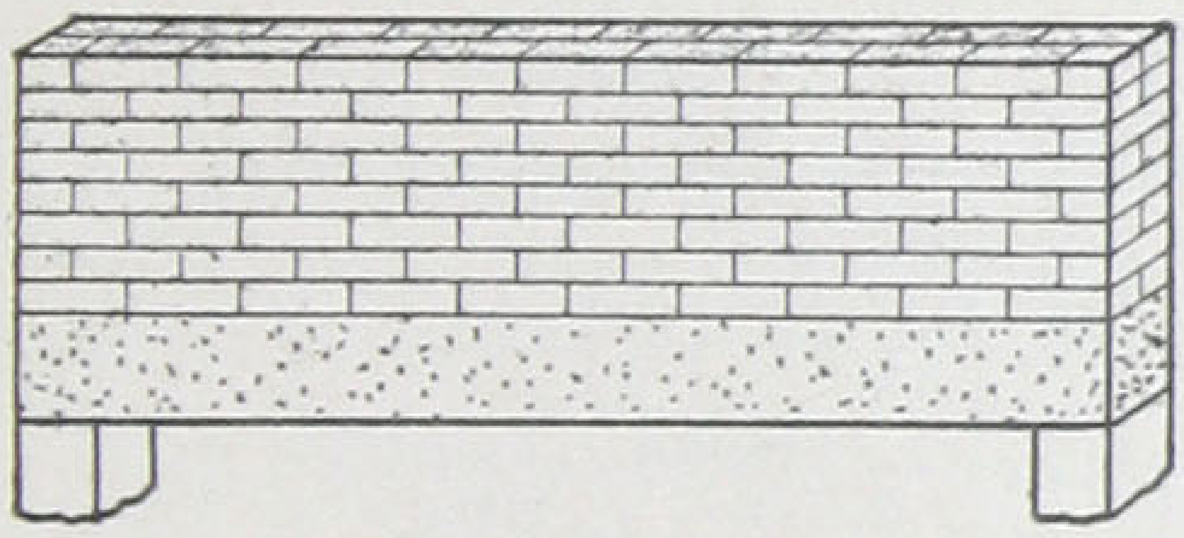


Fig. 33.—Example of uniformly loaded beam.

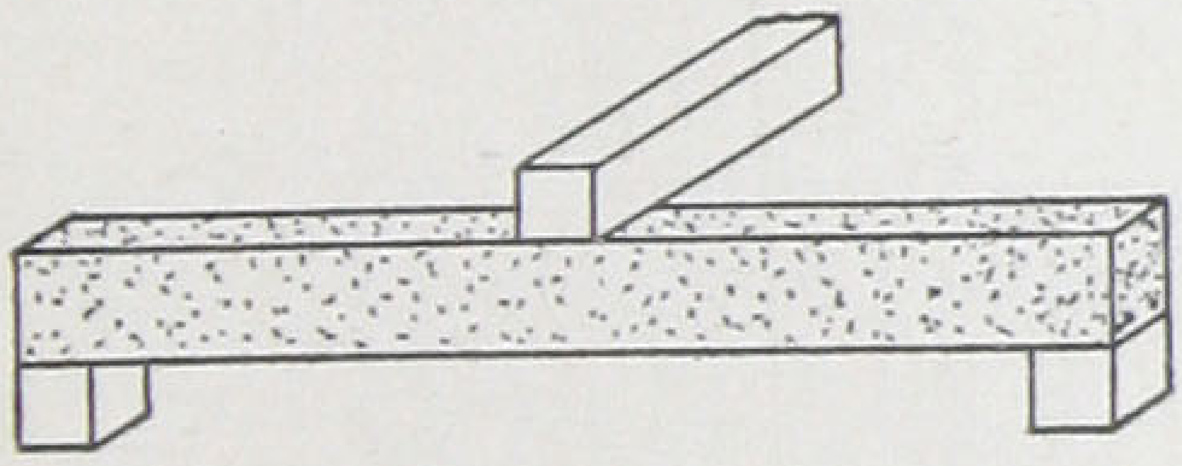


Fig. 34.—Example of beam with concentrated load.

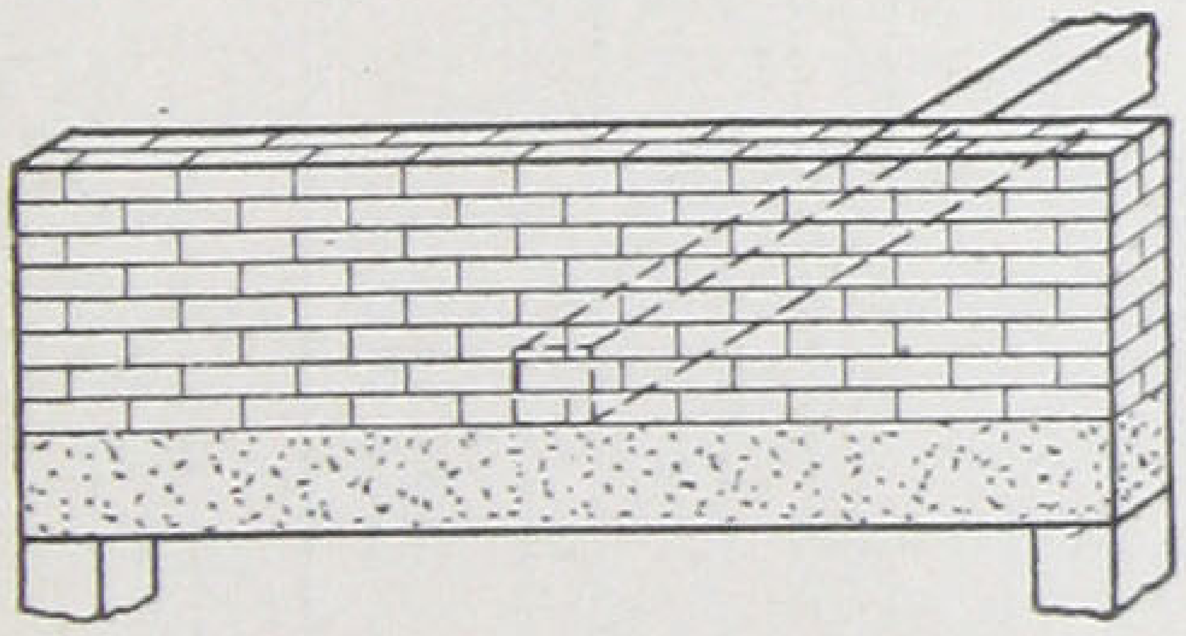


Fig. 35.—Example of beam carrying a combined uniform and concentrated load.

load. Figure 34. If the beam carries both the wall and the load from another beam, there would be a combination loading, Fig. 35.

The superimposed load, or the load that the beam carries, is called the live load.

The weight of the beam itself is called the dead load. The dead as well as the live load must always be taken into consideration in design. A beam must be designed sufficiently strong to transmit its load to its supports.

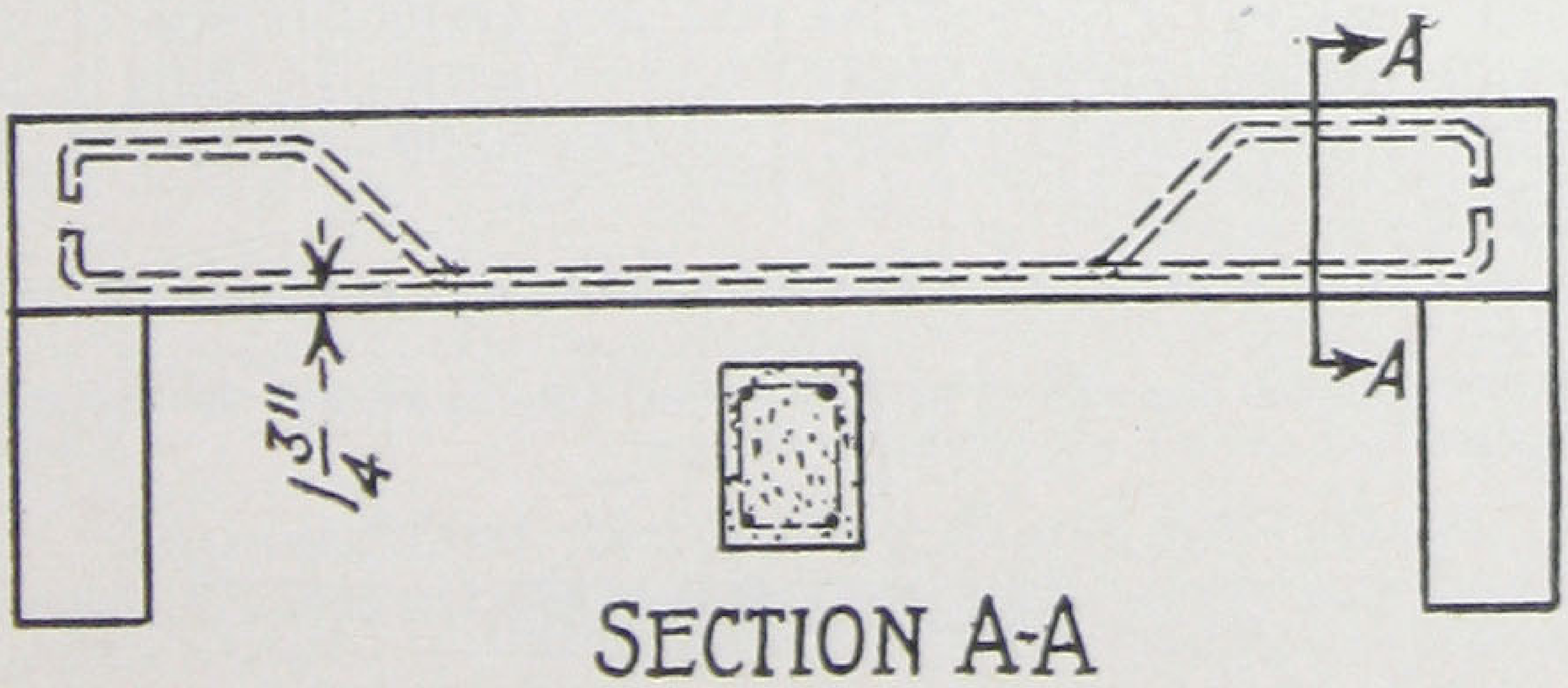



Fig. 36.—Typical reinforcing for concrete beam. Only the main reinforcing is shown. In actual practice stirrups are installed as shown in Figure 32.

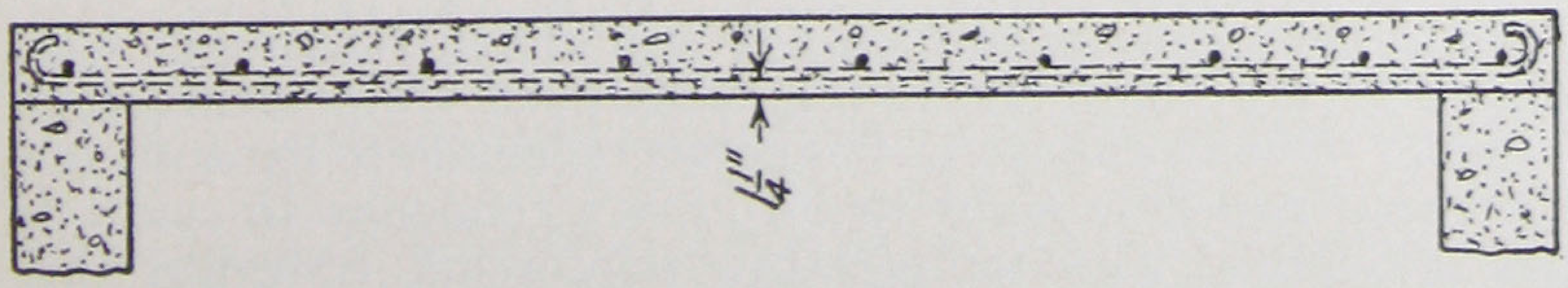



Fig. 37.—Slab reinforcing.

## TABLE 5

**Total Safe Live Loads in Pounds Uniformly Distributed, for Simple Beams. (See Figure 36)**

| Depth of Beam in Inches | Span in Feet 5 | 6 | 7 | 8 | 9 | 10 | Depth to Steel | Depth below Steel | Steel Area * |
|---|---|---|---|---|---|---|---|---|---|
| | **For Beams 6 Inches Wide** | | | | | | | | |
| 8 | 2760 | 2160 | 1764 | 1440 | 1188 | 960 | 7.00 | 1.00 | .258 |
| 9 | 3390 | 2736 | 2226 | 1824 | 1512 | 1260 | 7.75 | 1.25 | .282 |
| 10 | 4380 | 3528 | 2900 | 2400 | 2000 | 1680 | 8.75 | 1.25 | .318 |
| 11 | 5490 | 4428 | 3654 | 3072 | 2592 | 2220 | 9.75 | 1.25 | .354 |
| 12 | 6720 | 5472 | 4536 | 3840 | 3240 | 2760 | 10.75 | 1.50 | .396 |
| | **For Beams 8 Inches Wide** | | | | | | | | |
| 8 | 3680 | 2880 | 2352 | 1920 | 1584 | 1280 | 7.00 | 1.00 | .344 |
| 9 | 4520 | 3648 | 2968 | 2432 | 2016 | 1680 | 7.75 | 1.25 | .376 |
| 10 | 5840 | 4704 | 3867 | 3200 | 2667 | 2240 | 8.75 | 1.25 | .424 |
| 11 | 7320 | 5904 | 4872 | 4096 | 3456 | 2960 | 9.75 | 1.25 | .472 |
| 12 | 8960 | 7296 | 6048 | 5120 | 4320 | 3680 | 10.75 | 1.50 | .528 |
| | **For Beams 10 Inches Wide** | | | | | | | | |
| 10 | 7300 | 5880 | 4760 | 4000 | 3330 | 2800 | 8.75 | 1.25 | .530 |
| 11 | 9150 | 7380 | 6090 | 5120 | 4320 | 3700 | 9.75 | 1.25 | .590 |
| 12 | 11200 | 9120 | 7560 | 6400 | 5400 | 4600 | 10.75 | 1.50 | .660 |
| 13 | 13000 | 10440 | 8680 | 7360 | 6300 | 5400 | 11.50 | 1.50 | .700 |
| 14 | 15300 | 12480 | 10430 | 8800 | 7560 | 6500 | 12.50 | 1.50 | .760 |

*See Table 8 for size of rods.

Based on information contained in "Concrete, Plain and Reinforced," by Taylor and Thompson.

Unit stress for concrete considered as 500 pounds per square inch; for steel as 14,000 pounds per square inch, extra conservative design.

## FLOOR SLABS

The floor slab, between the beams, is considered as a series of little beams laid side by side although of course, the concrete is all poured at one time. The reinforcing is, therefore, very much the same as for beams.

Slabs have also another kind of reinforcing running at right angles to the main reinforcing, known as temperature reinforcing. Due to change in temperature, concrete expands and contracts, and floor slabs would have a tendency to crack on this account. The temperature reinforcing prevents this. See Figure 37.

When an opening in the floor slab is required for a stairway or other reason, be sure that the reinforcing is not placed as shown in Figure 38 but correctly as shown in Figure 39.

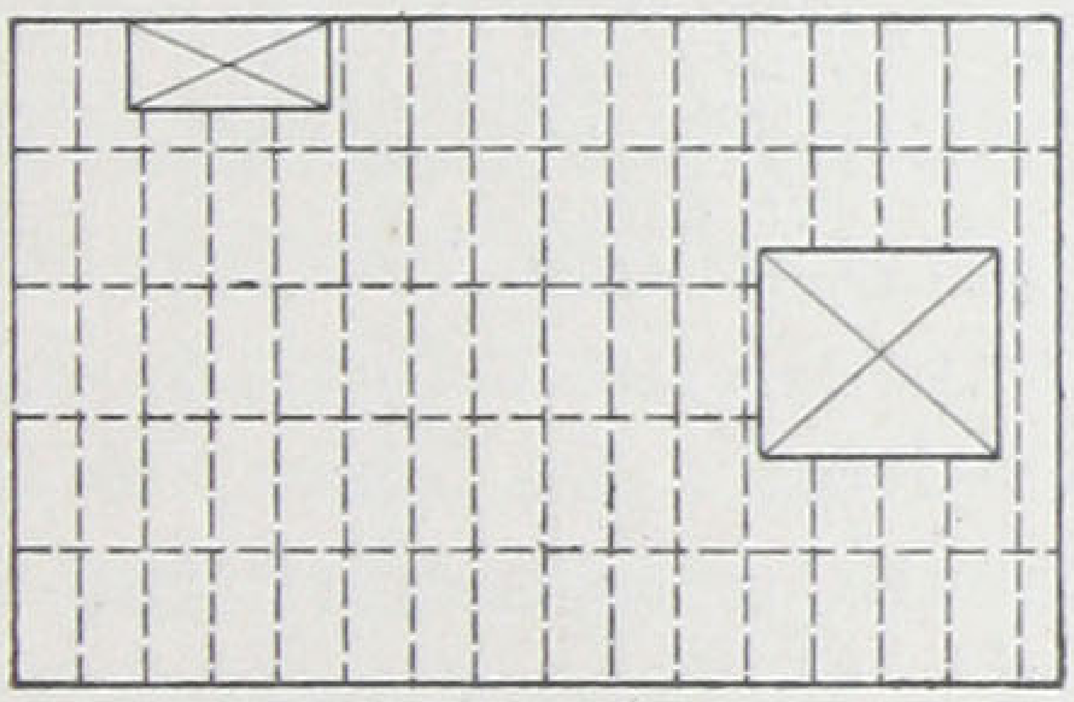


Fig. 38.—Wrong method.

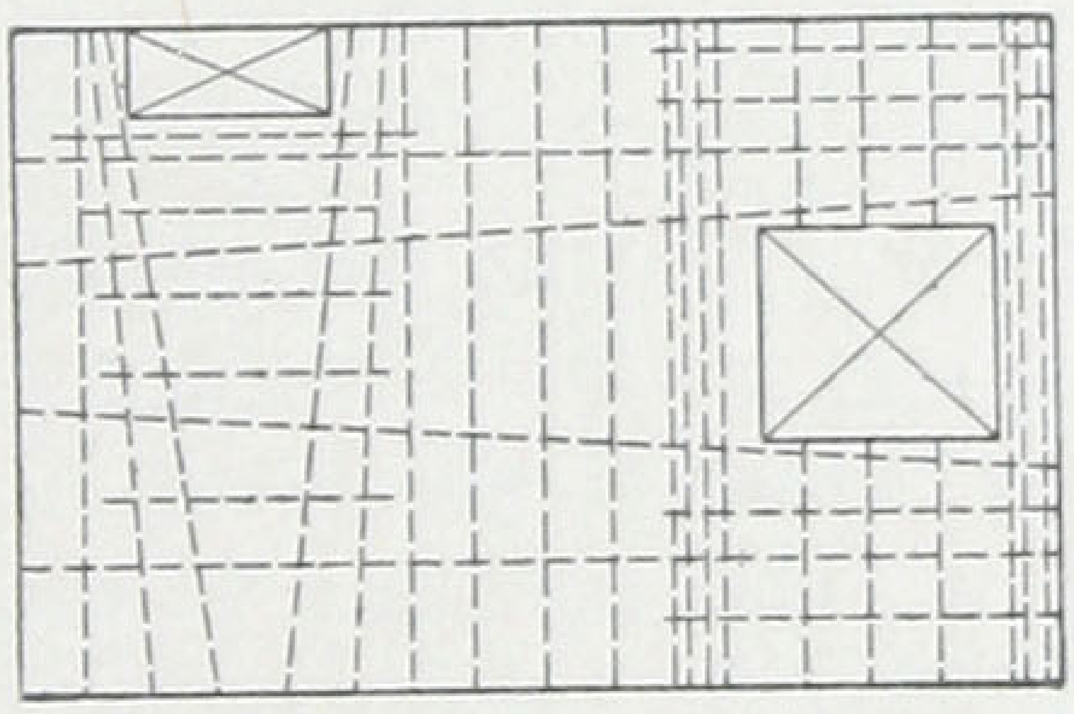


Fig. 39.—Right method.

## TABLE 6
## SAFE LOADS FOR CONCRETE SLABS
### Total Safe Loads, Uniformly Distributed, in Pounds per Square Foot, Slab Supported Along Two Sides

| Thickness of Slab Inches | SPAN—IN FEET | | | | | | | Round Reinforcing Bars* Transverse Between Supports |
|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 10 | 12 | |
| 4 | 433 | 259 | 164 | 107 | 71 | 27 | | ½ in.—spaced 8½ in. |
| 4½ | | 360 | 233 | 156 | 106 | 48 | | ½ in.—spaced 7¼ in. |
| 5 | | 468 | 319 | 218 | 152 | 75 | 33 | ½ in.—spaced 6¼ in. |
| 5½ | | | 414 | 286 | 203 | 105 | 52 | ⅝ in.—spaced 8¾ in. |
| 6 | | | 520 | 362 | 260 | 139 | 74 | ⅝ in.—spaced 7¾ in. |

*The amount of longitudinal or temperature reinforcing—parallel to supports—depends on area of slab. For small and medium size slabs ⅜ in. round bars spaced 12 in. apart will be sufficient.

### Square Slabs (Supported Along Four Sides)
### Safe Load, Uniformly Distributed, in Pounds per Square Foot

| Thickness of Slab Inches | SIZE OF SLAB—IN FEET | | | | | | | 2-Way Round Reinforcing Bars† |
|---|---|---|---|---|---|---|---|---|
| | 6x6 | 7x7 | 8x8 | 9x9 | 10x10 | 12x12 | 14x14 | |
| 3 | 150 | 100 | 67 | 45 | 28 | | | ⅜ in.—spaced 7 ″ each way |
| 3½ | 253 | 174 | 123 | 88 | 63 | 30 | | ⅜ in.—spaced 5¾″ each way |
| 4 | 378 | 264 | 192 | 140 | 104 | 58 | 28 | ½ in.—spaced 8½″ each way |
| 4½ | | 368 | 268 | 200 | 152 | 98 | 50 | ½ in.—spaced 7¼″ each way |
| 5 | | 498 | 366 | 278 | 212 | 128 | 78 | ½ in.—spaced 6¼″ each way |

†Square slabs are reinforced in two directions, bars lying at right angles to each other; in other words, in a 3 in. thick square slab the reinforcing will consist of 2 systems of bars at right angles to each other and *each* system consisting of ⅜ in. round rods spaced 7-in. on centers.

## Concrete Columns

The loads from the beams and girders are carried to the columns which must be designed accordingly.

Concrete columns of slender proportions should be avoided—the length should not exceed fifteen times the diameter.

Short columns or piers may be built without reinforcement but good practice requires it for safety in construction and to guard against possible eccentric loading. In case of such loading, the column would have a beam action with one side in tension. Reinforcement should, therefore, always be placed within two inches of the surface—not at the center.

Reinforcement may consist of:
(1) vertical, or longitudinal rods; or
(2) bands, hoops or spirals; or
(3) a combination of these.

Longitudinal reinforcement is held in place by means of bands or ties placed at frequent intervals; ¼ inch wire hoops placed on 12 inch centers horizontally is common practice. The amount of longitudinal reinforcement usually runs from 2% to 4% of the column area.

In the case of circular reinforcement, the hoops, bands, or spirals should not be less than 1% of the volume of concrete enclosed.

## STEEL FOR REINFORCEMENT

Steel for reinforcement consists of round or square bars or different kinds of wire mesh.

Bars can be bought from the manufacturers direct or from dealers. The price is based on so much per cwt. for bars ¾ inches or over, with an increase in price for the smaller sized bars. In many cases if the builder so wishes, he can submit to the dealer the plans of the structure and buy from him the bars and stirrups properly bent.

The first step is to make a list of the steel needed. This list should show the location, size, length and dimension of the bars required. The bars larger than ¼ inch or perhaps ⅜ inch are usually ordered to the exact length required so that

# STEEL BENDING SHEET

## COLUMN STEEL

| COL. NO. | NO. REQ'D | VERTICAL STEEL: LENGTH | SIZE | NO. BARS EACH COL. | TOTAL NO. BARS | HOOPS: SIZE | L'NGTH | DIMENSIONS | NO. EACH COL. | TOTAL REQ'D |
|---|---|---|---|---|---|---|---|---|---|---|
| C-1 | 4 | 18'-1" | 5/8" ϕ | 6 | 24 | 1/4" ϕ | 49 1/2" | 10 5/8", 6 5/8", 16 5/8" | 30 | 120 |
| C-2 | 10 | 18'-1" | 5/8" ϕ | 6 | 60 | 1/4" ϕ | 76 1/2" | 26 5/8", 8 5/8" | 15 | 150 |

## GIRDER STEEL

| GIRDER NUMBER | TOTAL NO. OF GIRDERS | STRAIGHT BARS: NO. | SIZE | LENGTH | TOTAL | DOUBLE BEND BARS: NO. | SIZE | L'GTH | A | B | C | D | E | F | X | Y | TOTAL NO. | STIRRUPS: SIZE | LENGTH | NUMBER | DIMENSIONS | TOTAL NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G-1 | 4 | 4 | 1" ϕ | 26'8" | 16 | 4 | 1" ϕ | 26'-8" | 8'6" | 2'0" | 5'6" | 2'0" | 8'6" | 2'0" | - | - | 16 | 1/2" ϕ | 61 1/2" | 26 | 3", 25", 25", 8 1/2" | 104 |
| G-2 | 8 | 4 | 1 1/8" ϕ | 32'-6 | 32 | 4 | 1 1/8" ϕ | 33'-6 | 11'-9 | 2'0 | 6'0 | 2'0 | 11'-9 | 2'0 | - | - | 32 | 1/2" ϕ | 64 1/2" | 30 | 3", 3", 25", 25", 8 1/2" | 240 |
| G-3 | 4 | 4 | 1" ϕ | 32'-6" | 16 | 4 | 7/8" ϕ | 33'6 | 11'-9 | 2'-0 | 6'-0 | 2'-0 | 11'-9 | 2'-0 | - | - | 16 | 1/2" ϕ | 61 1/2" | 26 | 3", 25", 25", 8 1/2" | 104 |

no cutting of these bars on the job will be required. A typical list of the steel for a beam and girder floor is shown in the Steel Bending Sheet on page 47.

Before the steel is received on the job, racks should be built in order that it can be stored for proper checking; so that the proper length bar can be found as needed. As the steel is received it should be measured and placed in the proper position in the rack.

## Bending Steel

Reinforcing bars up to 1⅛ inch size can be bent cold by hand. Above this size it will be convenient to use a power bender or to heat the bars before bending, but the heat should never be more than a dull red.

The most simple device for bending bars is a bending table as shown in Figure 40. This consists of a heavy table with the legs preferably sunk into the ground to secure rigidity. The two plates "A" are adjusted to the proper position by means of bolts and the two plates "B" are spiked to the table in the proper position. The bending is done by means of slipping a long heavy pipe over the end of the rod to secure the necessary leverage. When the blocks are set for a certain

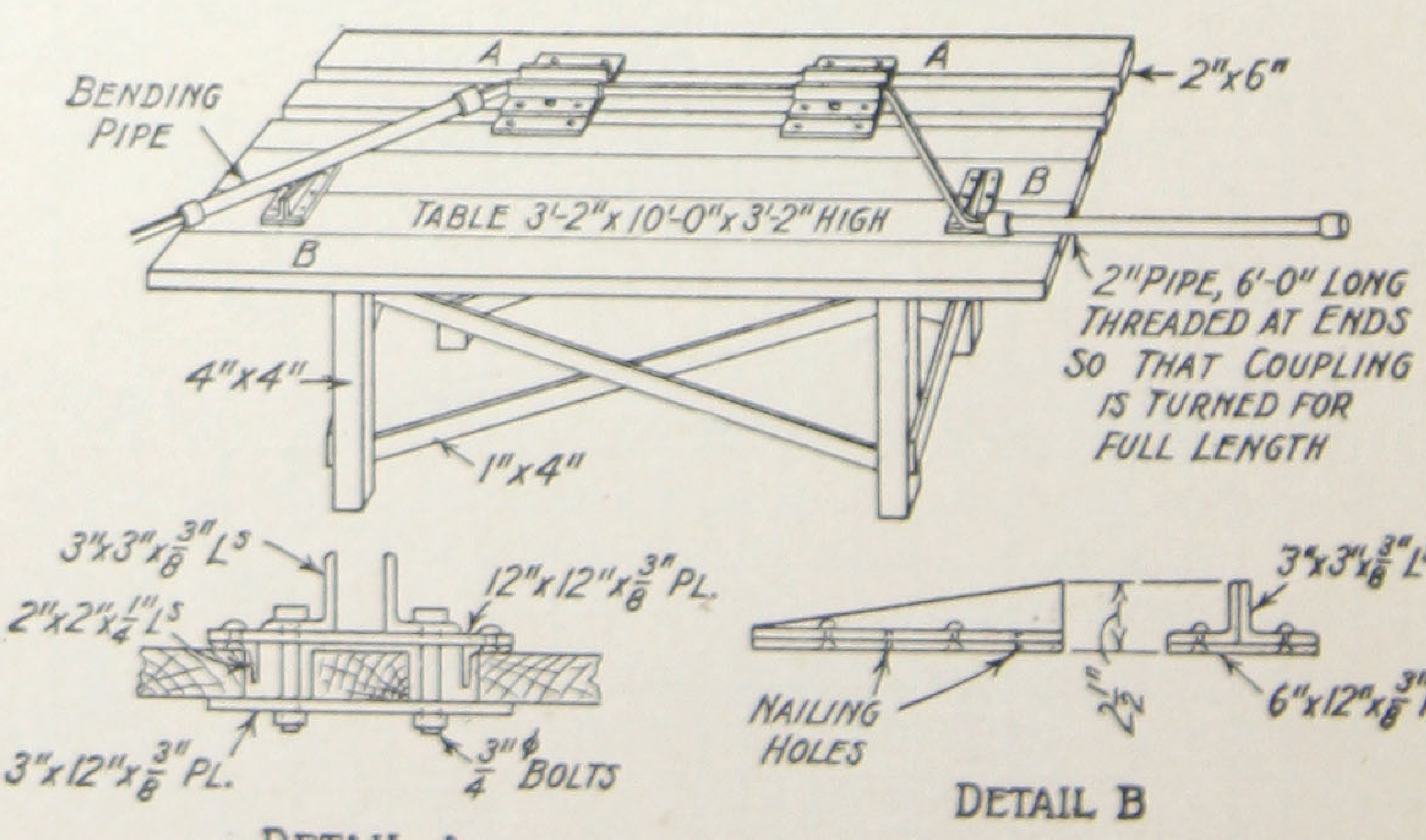



Fig. 40.—Bar bending table for use on the job.

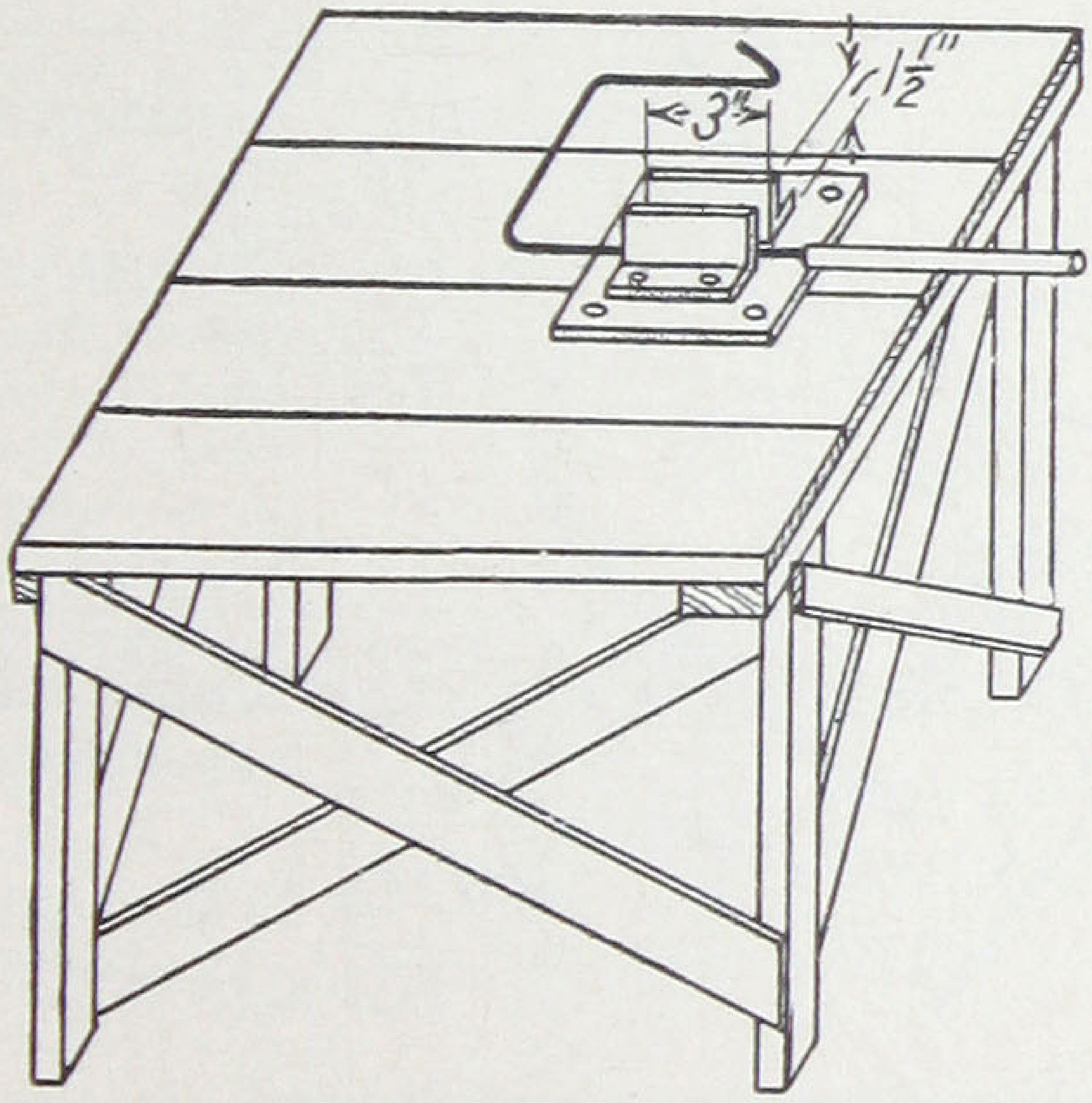


Fig. 41.—Device for bending light bars to be used as hoops and stirrups.

size of bend all bars in the building of these dimensions should be bent and the location of the bars painted on the end.

The next step will be the bending of hoops for column reinforcing and stirrups for beams and girders. This material is usually ¼ inch and is easily bent. The bars are first cut to the right length and the bends made by slipping a small pipe over the bar and bending in a small block as shown in Figure 41. Usually two may be bent at once.

## BENDING CIRCULAR STEEL

For silos, grain elevators and circular tanks it is necessary to bend the reinforcing steel in the form of hoops. In large diameter structures it is sufficient to bend the horizontal curved bars against the vertical steel. For small structures it will be necessary to bend it accurately to shape. One method is shown in Figure 42. The radius of the block should be less than half of the diameter of the hoops to allow for the spring in the steel. It is not necessary that it be absolutely accurate, as the hoops can be sprung slightly without destroying the circular shape. The ends of the hoops should be securely tied together and the best method is by a wire cable clip or if these are not available, by lapping the ends 40 diameters and wrapping with wire.

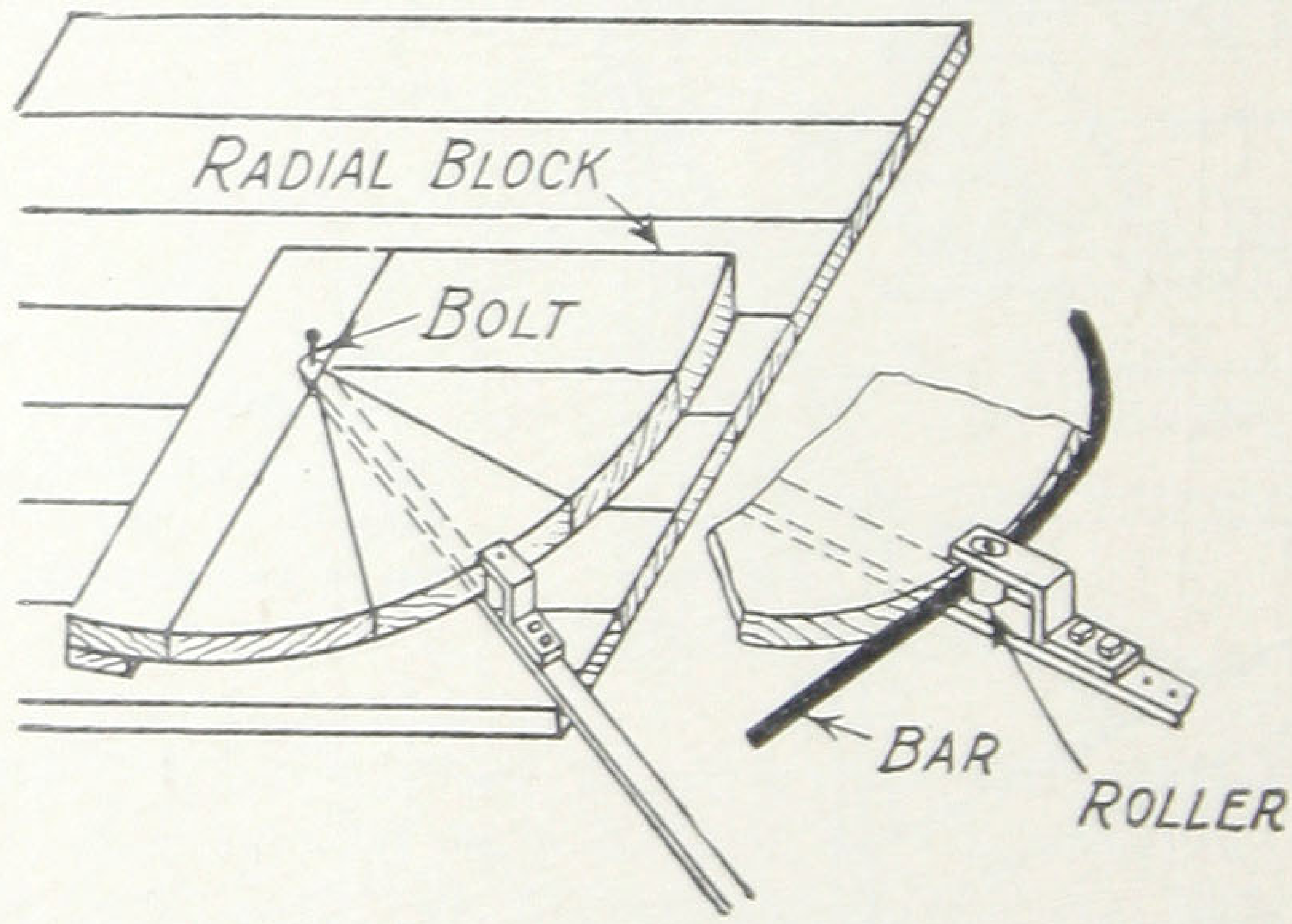



Fig. 42.—Device for bending steel bars in the form of hoops to be used as horizontal reinforcing in silos, circular tanks and grain bins.

## PLACING STEEL

Column reinforcing is assembled previous to placing it in the column forms, that is, the hoops are wired to the vertical rods and the reinforcement thus completely assembled is placed in the form. The most convenient method of assembling is shown in Figure 43.

Spiral reinforcing comes in the shape of coils, the coils being of any diameter required. Before placing in the column form the spirals must be attached to spacing bars of which there are usually three. It is usually better to order them attached to two spacers and shipped knocked down. When received on the job the spirals are opened up and the third spacing bar attached.

In placing beam and girdle reinforcing it is usually best to place stirrups and bars separately, the stirrups, of course, first. The stirrups are made with the two wings so that they will occupy their correct place in the beam with the bottom part about 1¼ inches from the bottom of

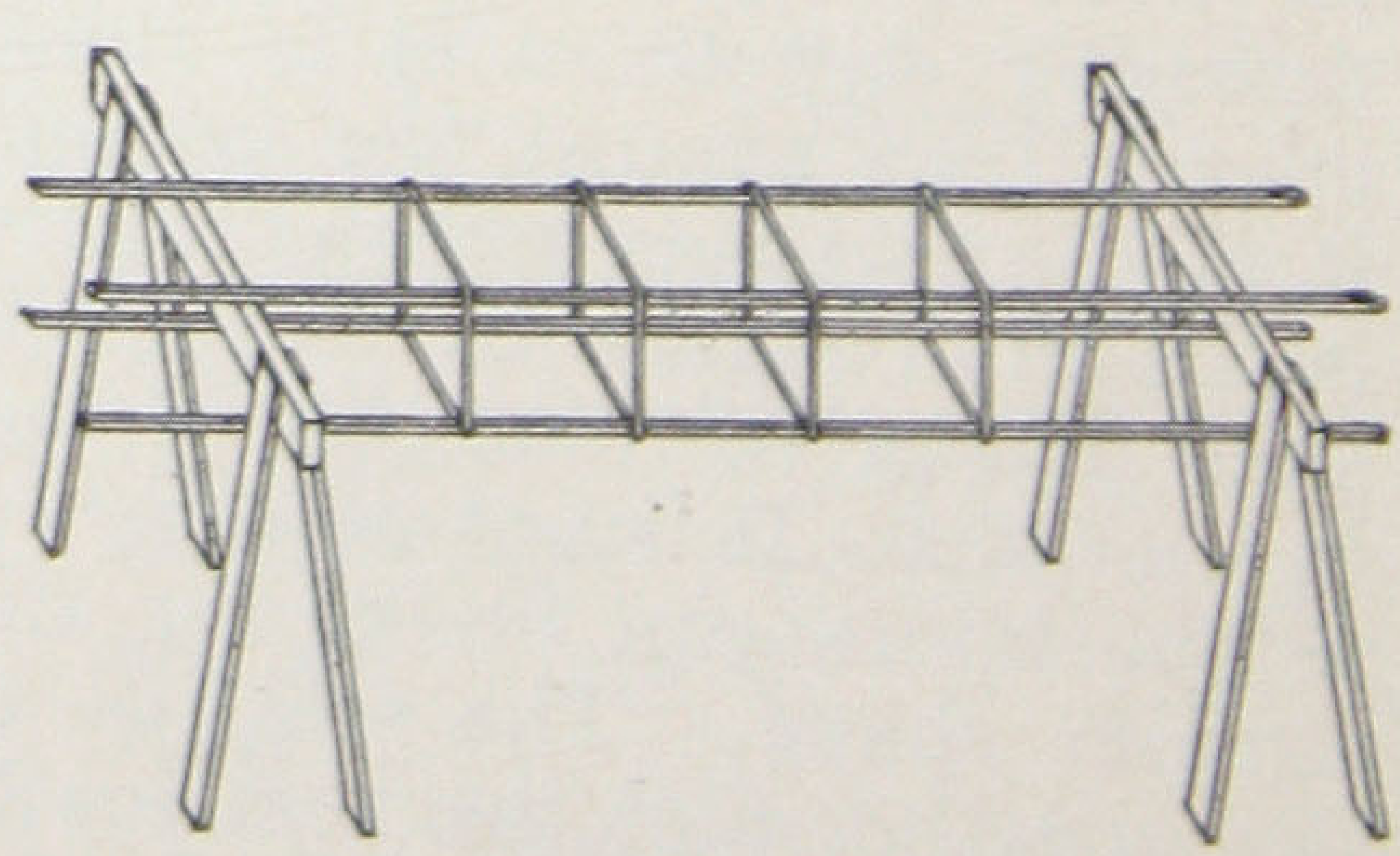


Fig. 43.—Convenient method for assembling column reinforcing.

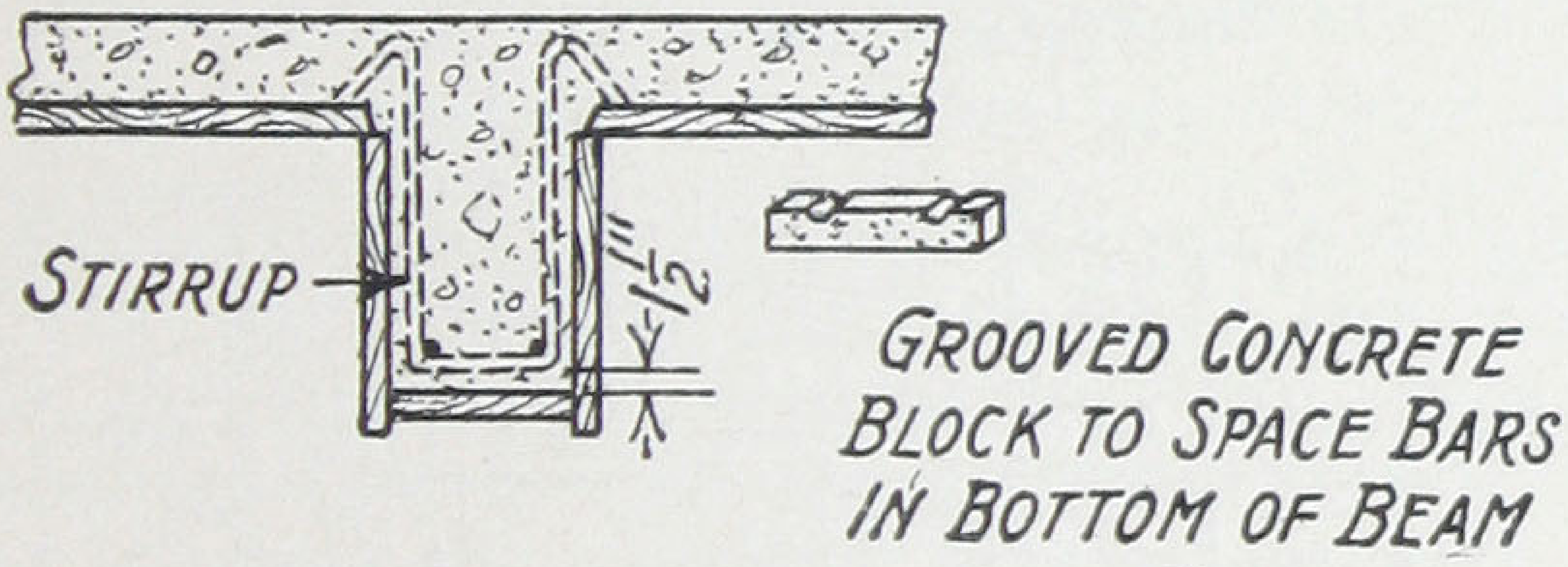



Fig. 44. Stirrup holding main reinforcing bars up from the bottom of a beam.

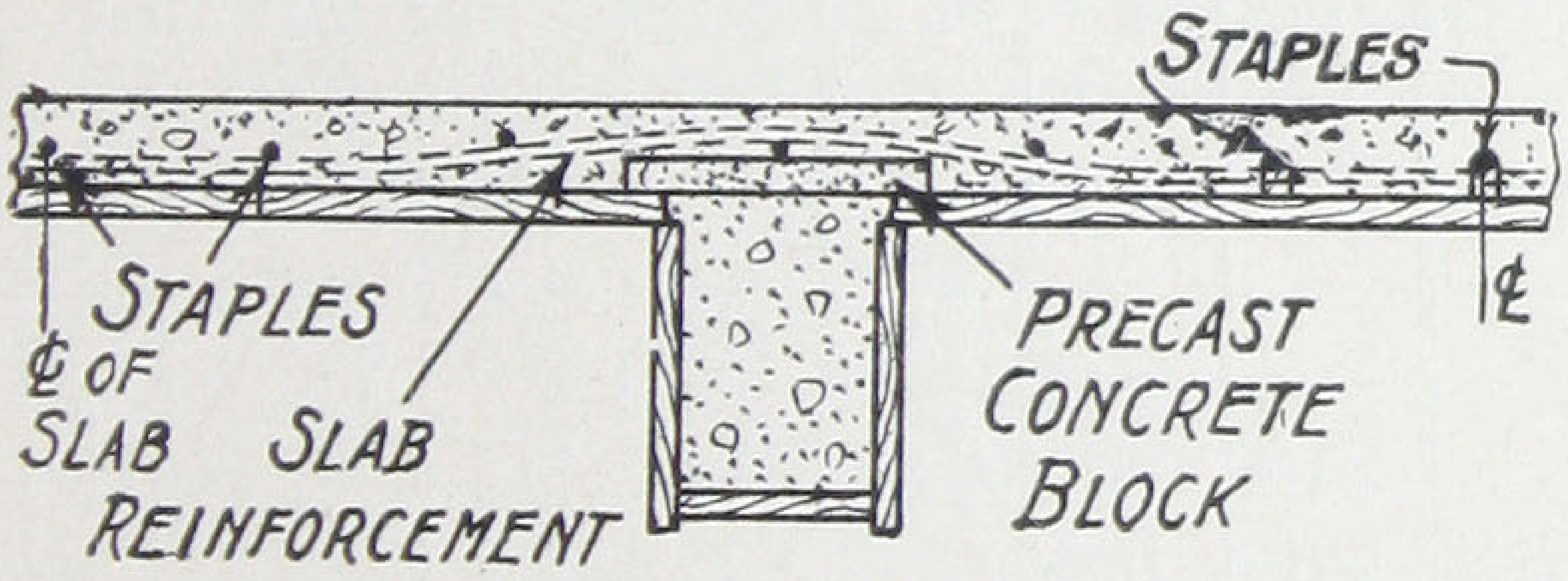



Fig. 45. Method of bending-up slab bars over top of beam.

the form. The larger bars rest on these stirrups thus giving the required 1½ inch of concrete below the rods for fireproofing as shown in Figure 44. In some cases the stirrups may not give the necessary support to the bars at the bottom and this can be taken care of by making small concrete blocks 1½ inches thick and placed in the bottom of the beam forms to support the bars.

In placing the slab steel in beam and girder construction it is necessary to have some means of support to keep the slab bars near the top. This can be done by the use of special reinforcement chairs. These chairs can be purchased from dealers in reinforcing specialties or a concrete block supporting a bar as shown in Figure 45 can be used.

In placing flat-slab steel it is necessary to support the steel over the column heads, at the approved height. This can be done by bending a bar in the form of a square and supporting it on pre-cast concrete blocks. The slab steel is then placed in the proper position and the necessary bends made by the use of a "hickey."

A "hickey" is a "T" shaped contrivance the upright portion made out of a ¾ inch round bar to which is welded a flat piece about 3 inches wide and ½ inch thick. The length of the cross piece is governed by the length of the bend to be made.

## TABLE 7

### Equivalent Spacing of Reinforcing Bars for Concrete Slabs

To be used in Substituting One Size Bar for Another Size

| ⅜" Bars | | ½" Bars | | ⅝" Bars | | ¾" Bars | | ⅞" Bars | | 1" Bars | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rd. | Sq. | Rd. | Sq. | Rd. | Sq. | Rd. | Sq. | Rd. | Sq. | Rd. | Sq. |
| | | | | | | | | | | 3" | 3¾" |
| | | | | | | | | | 3⅜" | 3½ | 4½ |
| | | | | | | | | 3 " | 3¾ | 4 | 5 |
| | | | | | | | | 3½ | 4½ | 4½ | 5¾ |
| | | | | | | | | 3¾ | 4¾ | 5 | 6¼ |
| | | | | | | 3 " | 3¾" | 4¼ | 5¼ | 5⅜ | 6¾ |
| | | | | | | 3¼ | 4⅛ | 4½ | 5⅝ | 6 | 7½ |
| | | | | | 3⅜" | 3¾ | 4¾ | 5 | 6½ | 6½ | 8½ |
| | | | | | 3½ | 4 | 5 | 5½ | 7 | 7 | 9 |
| | | | | 3 " | 3¾ | 4¼ | 5½ | 6 | 7½ | 7½ | 9½ |
| | | | | 3¼ | 4⅛ | 4¾ | 6 | 6½ | 8 | 8¼ | |
| | | | | 3½ | 4½ | 5 | 6½ | 7 | 8¾ | 9 | |
| | | | 3 " | 3¾ | 4¾ | 5½ | 6⅞ | 7⅜ | 9¼ | 9½ | |
| | | | 3¼ | 4 | 5 | 5¾ | 7⅜ | 8 | 10 | | |
| | | | 3½ | 4¼ | 5½ | 6 | 7¾ | 8¼ | | | |
| | | | 3⅝ | 4½ | 5¾ | 6½ | 8¼ | 8¾ | | | |
| | | 3 " | 3¼ | 4¾ | 6 | 6¾ | 8½ | 9¼ | | | |
| | | 3¼ | 4⅛ | 5¼ | 6½ | 7½ | 9½ | | | | |
| | | 3½ | 4½ | 5½ | 7 | 8 | 10 | | | | |
| | | 3¾ | 4¾ | 6 | 7½ | 8½ | | | | | |
| | | 4¼ | 5½ | 6½ | 8½ | 9½ | | | | | |
| | | 4½ | 5¾ | 7 | 9 | 10 | | | | | |
| | | 4¾ | 6 | 7½ | 9½ | | | | | | |
| | 3⅜" | 5 | 6⅜ | 8 | 10 | | | | | | |
| 3 " | 3¾ | 5¼ | 6¾ | 8¼ | | | | | | | |
| 3⅛ | 4 | 5½ | 7 | 8¾ | | | | | | | |
| 3⅜ | 4¼ | 6 | 7⅝ | 9⅜ | | | | | | | |
| 3⅝ | 4⅝ | 6½ | 8¼ | 10 | | | | | | | |
| 4 | 5⅛ | 7 | 9 | | | | | | | | |
| 4¼ | 5⅜ | 7½ | 9⅝ | | | | | | | | |
| 4½ | 5¾ | 8 | 10 | | | | | | | | |

**Explanation:** Often it is desirable to use a different size bar than the one specified for reinforcing slabs, because a certain size is in stock or left over from a previous job. This table will give the equivalent spacing for the new size of bar.

**For Example:** If the reinforcing of a slab is specified as ⅝" square bars, spaced 7" on centers, and it is desired to use ½" square bars, run down the column headed "⅝" square" to the spacing 7". Then go to the left along the same line until reaching the column "½" square" size. The spacing will be found to be 4½". This means that ½" square bars can be substituted for ⅝" square, provided the spacing is made 4½" on centers instead of 7".

Of course this table must be used with common sense and good judgment. It would be absurd to try to substitute a ⅞ or 1" bar when a ⅜" bar is specified and vice versa.

Steel placed as reinforcement must be free from oil or paint or scaly rust. In this connection the forms should be oiled before the steel is placed. The ordinary firm layer of rust is in no way objectionable and probably increases the bond between the steel and concrete.

Joints in reinforcing steel are made by lapping the bars side by side a distance of 40 diameters—20 inches for ½ inch round rods.

The steel must be accurately placed as called for in the plans; otherwise the concrete will not have the strength for which it was designed. Care must be taken, therefore, that the reinforcing steel is tied together so that it will not be displaced during the pouring of the concrete. This tying is done with No. 14 or No. 16 soft annealed iron wire. There are also many clip devices on the market for tying the intersections.

### TABLE 8
### WEIGHTS AND AREAS OF REINFORCING STEEL
**Sizes in Heavy Type Are Standard Sizes Stocked by Dealers**

| SIZE | Area (sq. in.) | Lbs. per Foot | Ft. per Ton of 2,000 lbs.* |
|---|---|---|---|
| | Sq. in. | Lbs. | Feet |
| **¼ inch round bars** | **.0491** | **.167** | **12,000** |
| ¼ inch square bars | .0625 | .213 | 9,390 |
| **⅜ inch round bars** | **.1105** | **.376** | **5,320** |
| ⅜ inch square bars | .1406 | .478 | 4,180 |
| **½ inch round bars** | **.1963** | **.668** | **3,000** |
| **½ inch square bars** | **.2500** | **.850** | **2,365** |
| **⅝ inch round bars** | **.3068** | **1.043** | **1,912** |
| ⅝ inch square bars | .3906 | 1.328 | 1,508 |
| **¾ inch round bars** | **.4418** | **1.502** | **1,331** |
| ¾ inch square bars | .5625 | 1.913 | 1,046 |
| **⅞ inch round bars** | **.6013** | **2.044** | **978** |
| ⅞ inch square bars | .7656 | 2.603 | 768 |
| **1 inch round bars** | **.7854** | **2.670** | **749** |
| **1 inch square bars** | **1.0000** | **3.400** | **588** |
| 1⅛ inch round bars | .9940 | 3.380 | 592 |
| **1⅛ inch square bars** | **1.2656** | **4.303** | **465** |
| 1¼ inch round bars | 1.2272 | 4.172 | 479 |
| **1¼ inch square bars** | **1.5625** | **5.313** | **376** |

*Reinforcing is generally sold by the ton. This column gives the number of feet of each size bar in one ton.

# CHAPTER III

# FORMS FOR CONCRETE

Forms must be tight, rigid, and strong enough to sustain the weight of the concrete. They must also be simple and economical and if to be used again, designed so that they may be easily removed and re-erected without damage to themselves or to the concrete. The different shapes into which concrete is formed mean that each job will present some new problems to be solved, but there are typical forms that will cover a large part of concrete construction.

Most forms at the present time are made of wood, although steel forms are often used for work with large, flat surfaces, particularly sidewalks, curbs, roads and retaining walls and columns where the forms are to be used repeatedly. It always must be borne in mind that ease in removal and erection are the largest factors in economical design of forms and each job should be thoroughly studied and forms designed with this point in view.

## Lumber for Forms

Lumber for forms will vary with the locality. The ideal combination is strength and lightness. White pine, spruce and the softer southern pines are the best. All lumber should be dressed at least on one side and both edges, and in most cases it will be cheaper to have it dressed on both sides. Since most forms are cleated, dressing is necessary in order that the face next to the concrete will be uniform. In footings and rough work that is not to show, practically any lumber can be used that will hold wet concrete. But for forms that are to be used again, the additional ease of cleaning will pay the cost of having the lumber dressed.

The edges may be cut square, mitred or tongued and grooved. The last method makes a more water-tight joint and tends to prevent warping. The mitred joint is used for lumber that has a tendency to swell so that the thin edge will crush against the next piece and give a tight joint.

It is seldom economical to rework second-hand lumber for forms. Old lumber must be pulled apart and nails drawn, after which it must be carefully cleaned. Even then it will usually have so much concrete adhering that it will dull tools very rapidly. It costs about twice as much to construct forms of old lumber. New lumber will be found cheaper in the end.

The thickness of the lumber varies according to its use. For short spans between supports, such as floor slabs and wall forms, 1 inch stock is commonly used; for columns either 1 inch or 1¼ inch, according to the spacing of the yokes; for beam sides and bottoms 2 inch. Heavier material is used for beams, as they must be strong and rigid to withstand the handling they receive when moved from floor to floor and to hold the weight of concrete between supports without deflection. In ordinary dressed lumber it is customary to give the sizes of the rough lumber from which it is worked up, and in the figures in this series sizes have been so noted. Thus 2″ D 4 S means 2-inch lumber dressed 4 sides; i. e., both sides and edges. This dressing cuts down the 2-inch thickness to about 1⅞ inches.

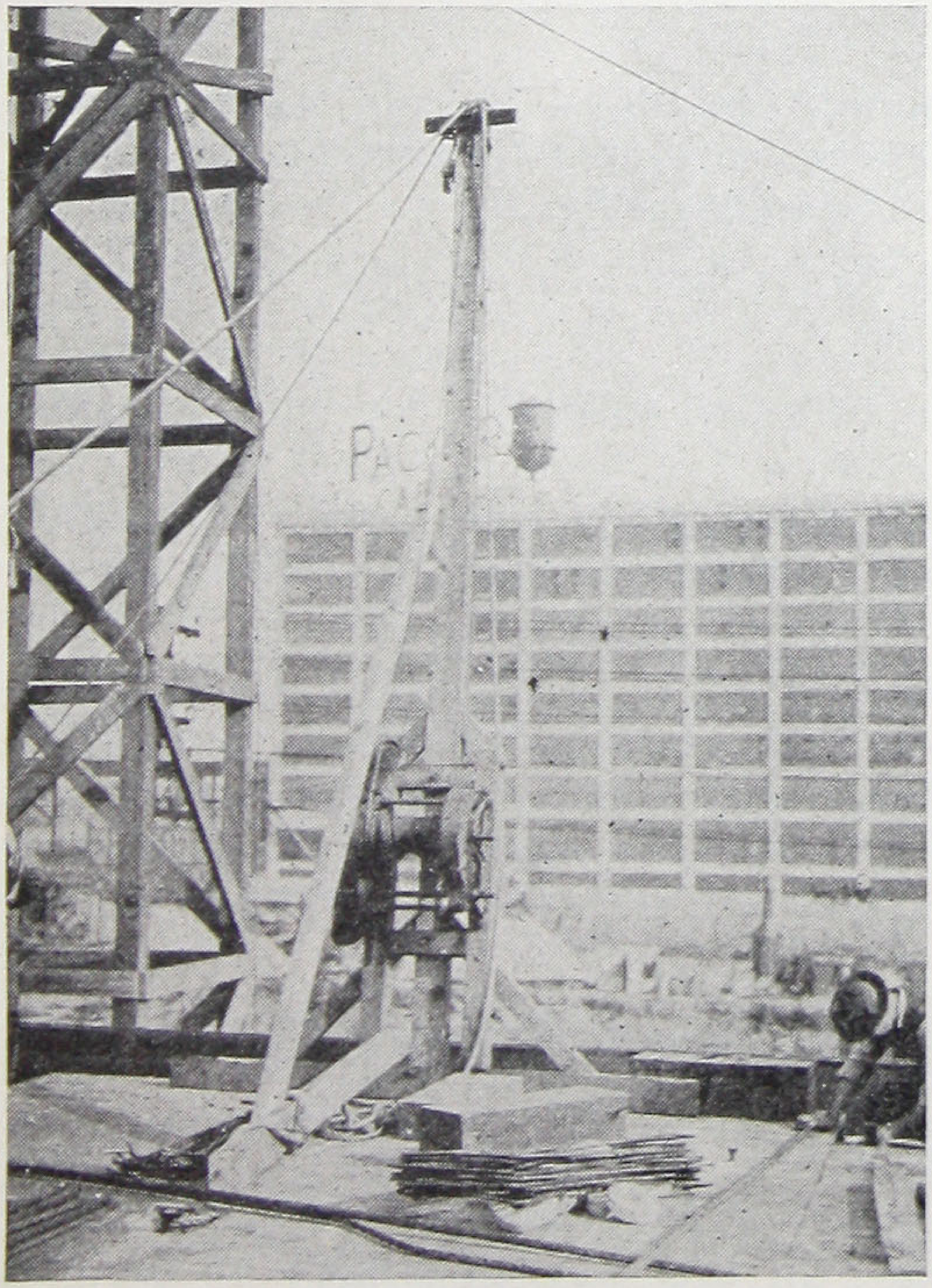


Fig. 46.—A "Jenny-Winch," by means of which light loads can be hoisted with a hand windlass.

## Removal of Forms

Any rules for time of removal of forms must be approximate and must be used in conjunction with experience and judgment, but those given below by Taylor and Thompson, in their book, "Concrete Costs," will serve as a guide:

"Walls in mass work: One to three days, or until the concrete wall will bear pressure of the thumb without indentation."

"Thin walls: In summer, two days; in cold weather, five days."

"Columns: In summer, two days, in cold weather, four days, provided the girders are shored to prevent any appreciable weight reaching the columns."

"Slabs up to seven foot spans: In summer, six days; in cold weather, two weeks."

"Beam and girder sides: In summer, six days; in cold weather, two weeks."

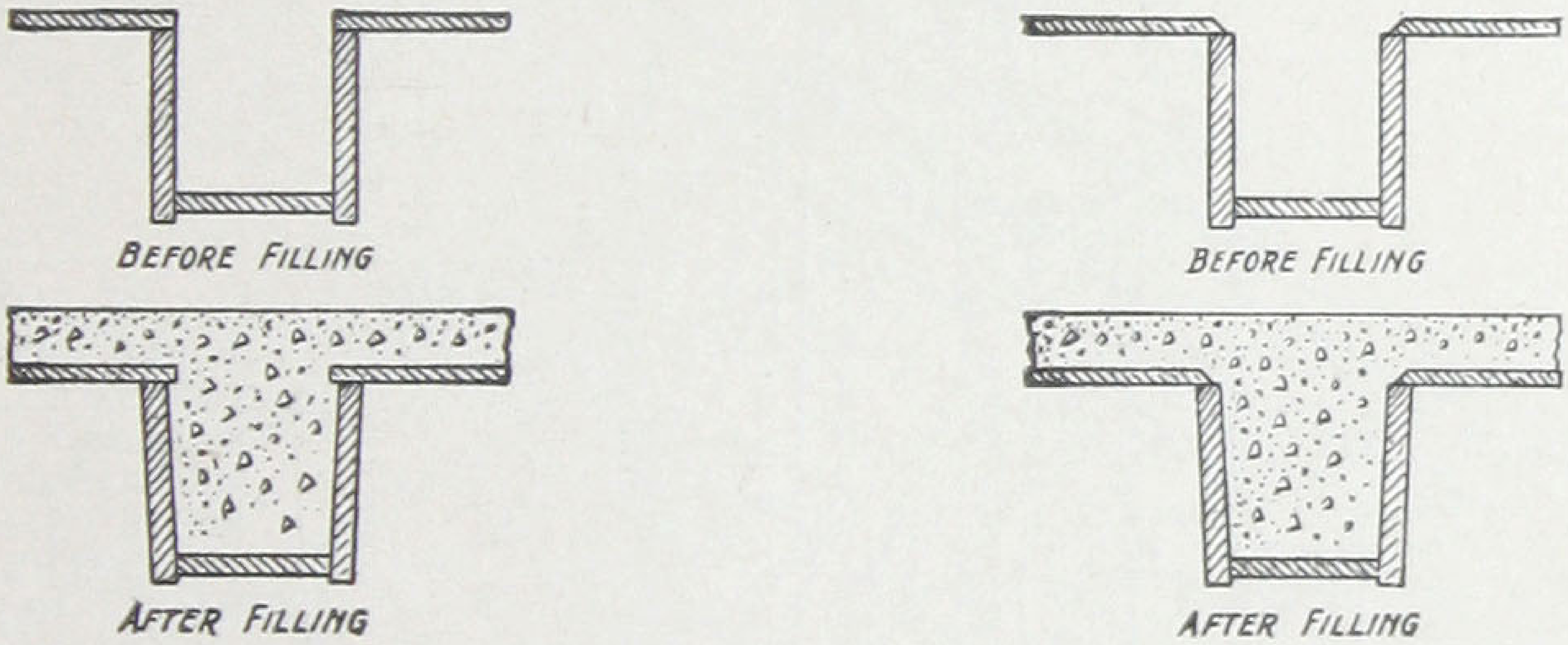
"Beam and girder bottoms and long span slabs: In summer, ten days or two weeks; in cold weather, three weeks to one month."

These times as given are conservative. Column and wall forms are often stripped within twenty-four hours, and girders and floor slabs in three days, but all floor work must be properly shored for at least twenty-eight days, as it must not only support its own weight but that of the construction above it.

If properly constructed and with ordinary care taken in stripping and handling, forms may be used ten or twelve times in building construction. This will cover practically any structure. If they are to be used more often than this, the forms must be especially well made and more than ordinary care used in stripping. In this way they may be used as many as fifteen times.

## Clearance

Forms must be designed so that they can be easily removed. There always will be slight movements of the forms due to




Wrong Method. Fig. 47. Right Method.

the weight of the concrete. It is, therefore, necessary to give particular care to the joints made by the different units of the forms and allow sufficient clearance for any movement of the forms. This is well illustrated in the joint where a floor panel rests on a beam side. The panel should have a beveled edge and only project about half way onto the beam side. If the edge of the panel is made flush with the inside face of the beam before the form is filled, it will be found to be projecting into the concrete of the beam when the time comes to strip it, due to the sides of the beam spreading slightly from the weight of the concrete. Figure 47 shows the right and wrong ways to make such connection.

The upper figures show the forms before filling ana the lower figures the position the beam sides take due to the pressure of the concrete.

## Foundation and Wall Forms

The construction of foundation and wall forms is clearly shown in Figures 48 and 49, on the following page. In most cases it is necessary to provide both an inner and an outer form, because the earth side of the excavation will not stand up firmly. Both types of foundation wall-forms are shown, however. The sectional wall-form shown in Figure 52 is best used where only a small amount of wall is to be built. Steel sectional forms are better suited to continued use where a considerabie amount of wall is called for.

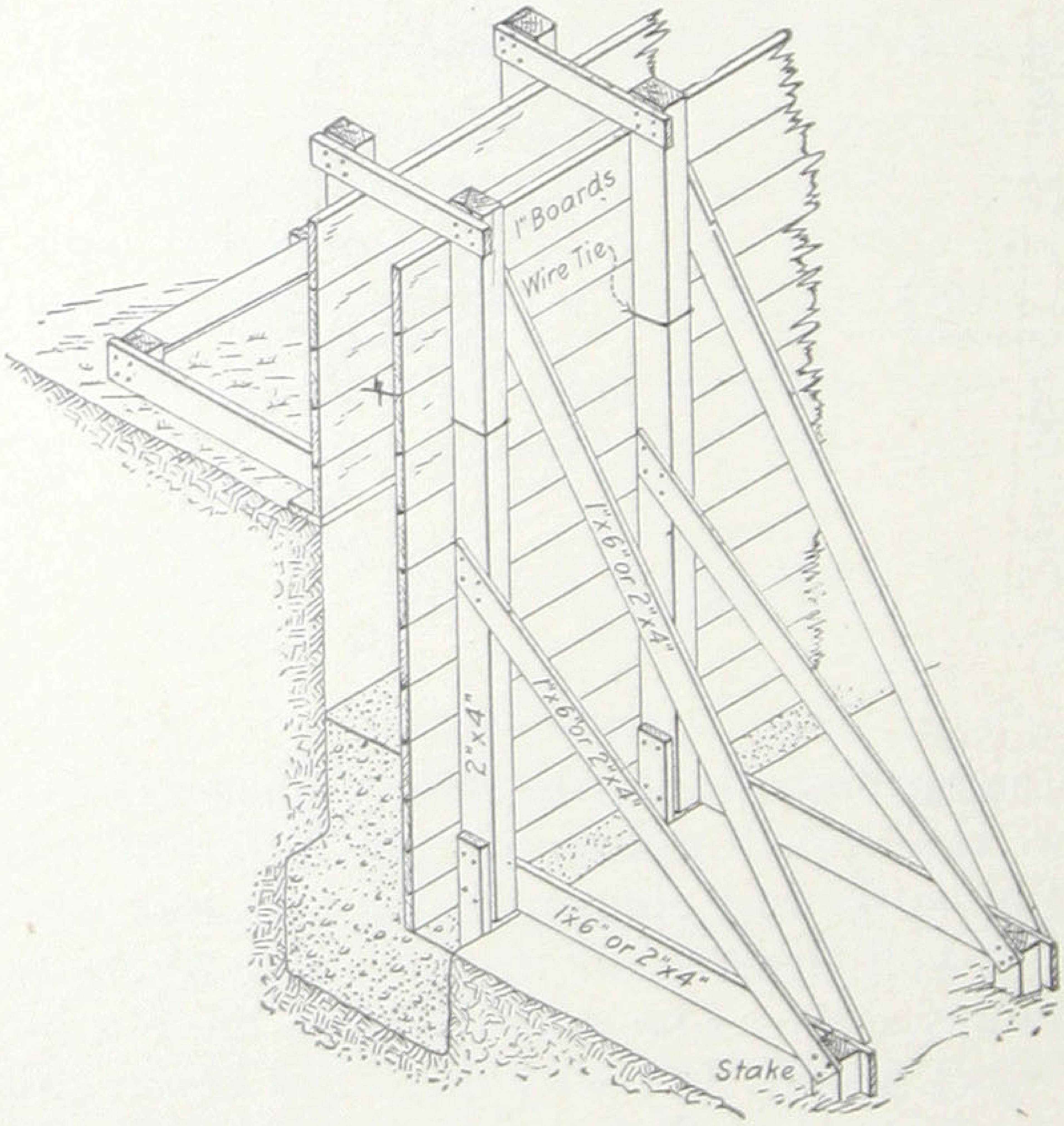



Fig. 48.
A wall form for foundation walls and cellar walls built in firm ground, in which the earth side of the excavation will stand upright. Great care must be exercised in filling this form, so as not to knock earth into the fresh concrete.

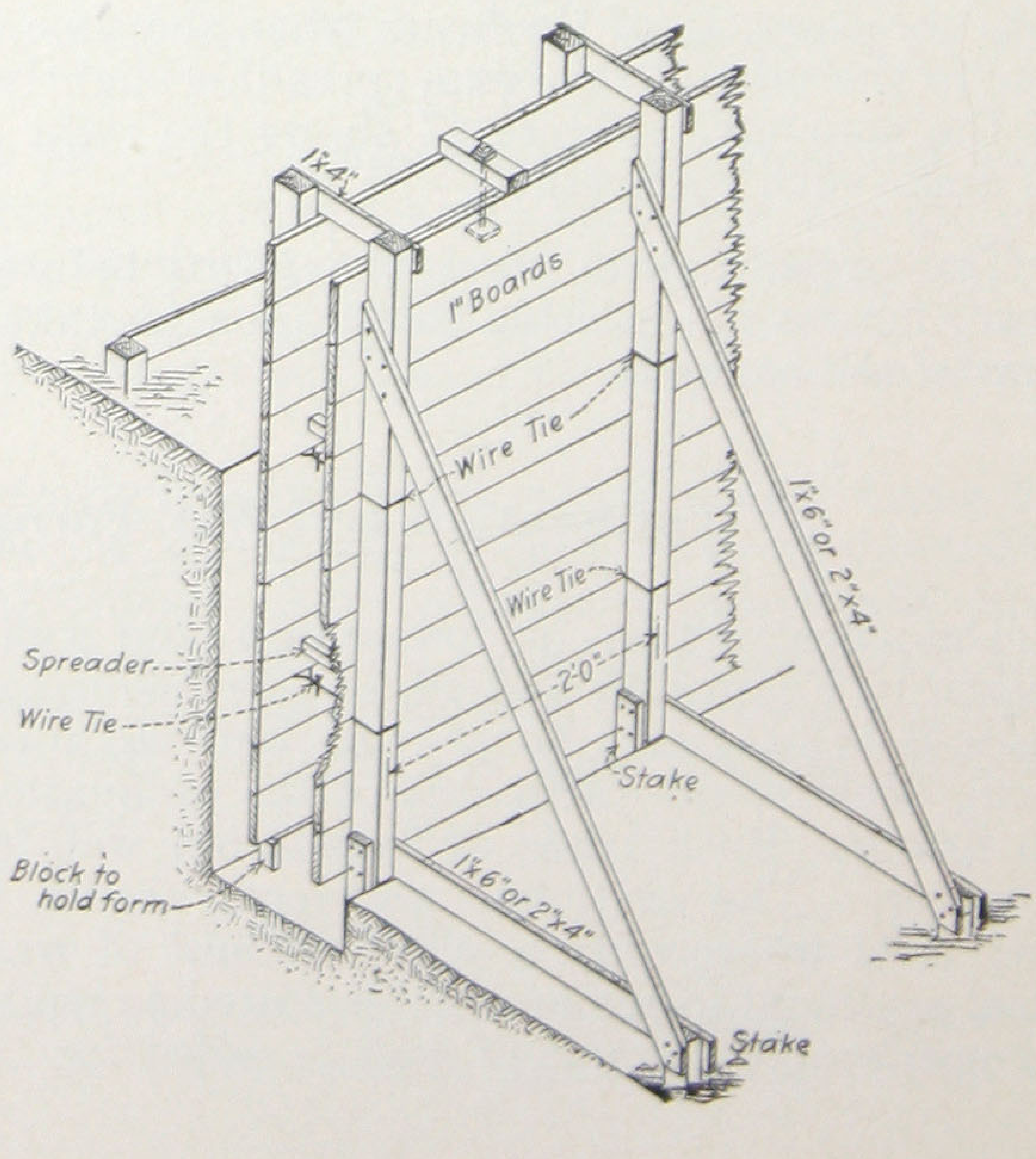



Fig. 49.
Form for foundation and cellar wall located in ground which is not firm—in which case both inside and outside forms are necessary. This form is more generally used, than the form shown above. In most cases the earth side of the excavation will slope back at an angle instead of standing up vertically as shown in the cut.

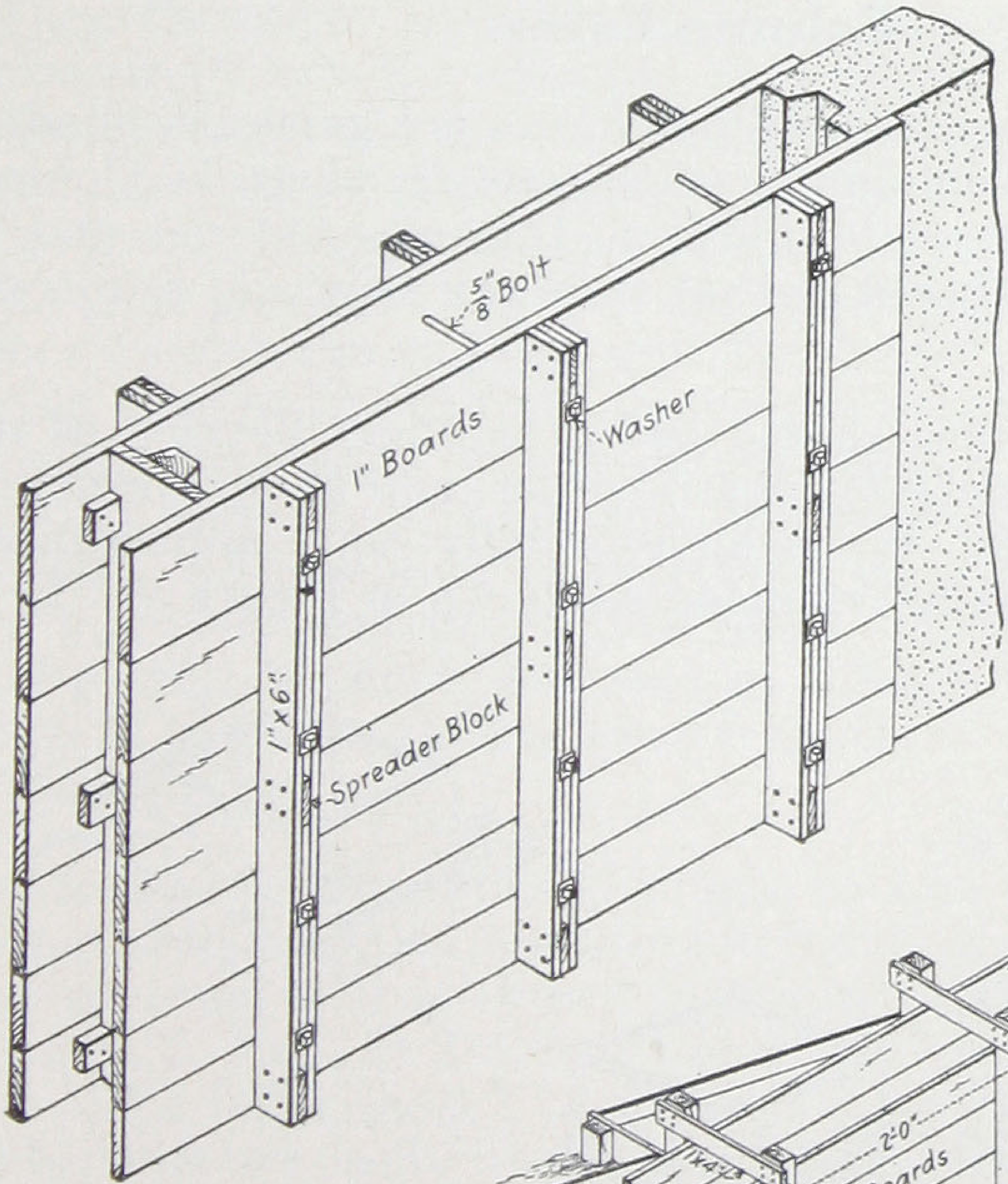



Fig. 50.
Form for sectional wall. Notice dovetail formed in wall already poured for the purpose of holding sections of wall in line.

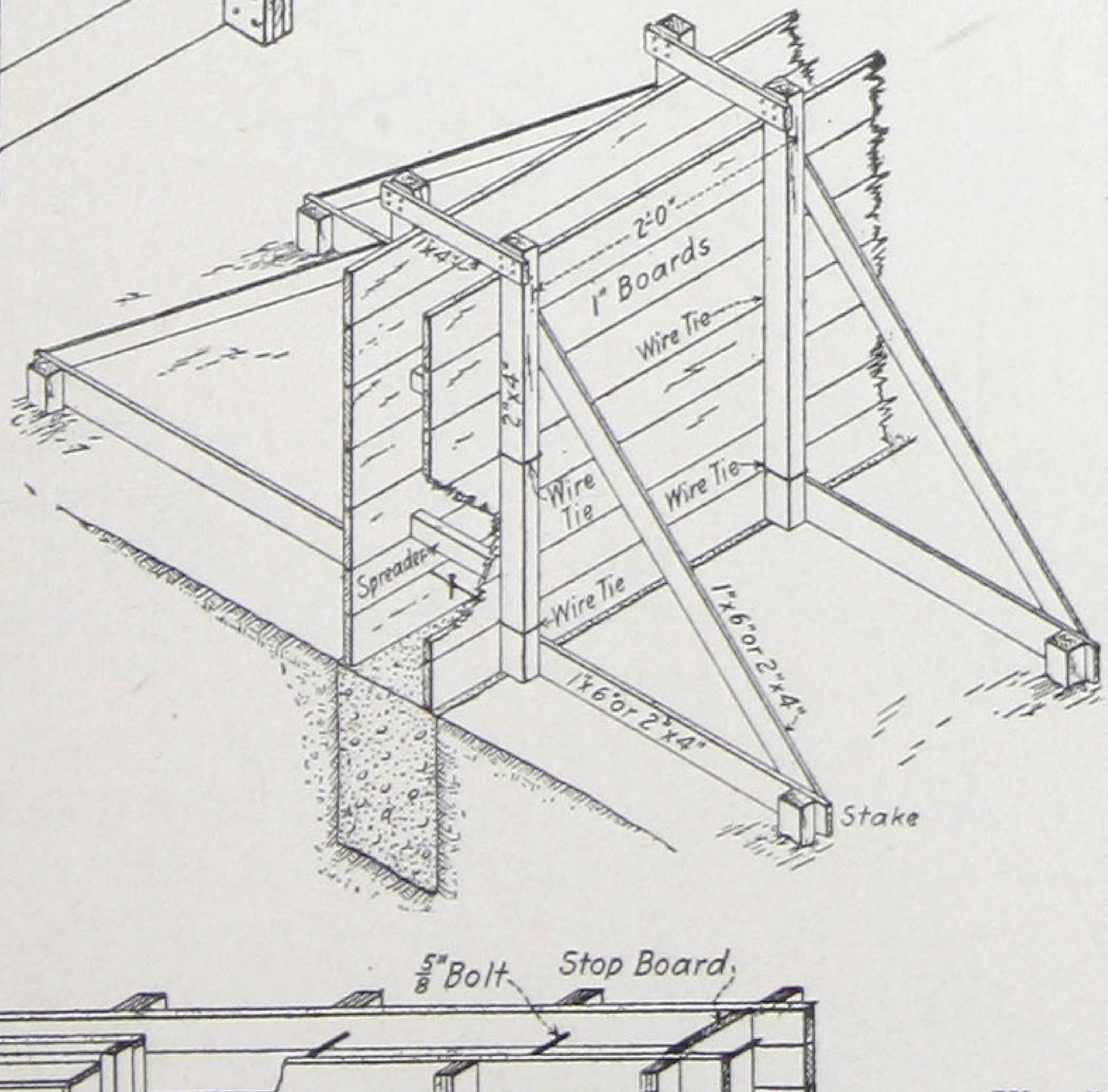



Fig. 51.
Wall form for wall above ground. Notice that wall below ground is poured in trench.

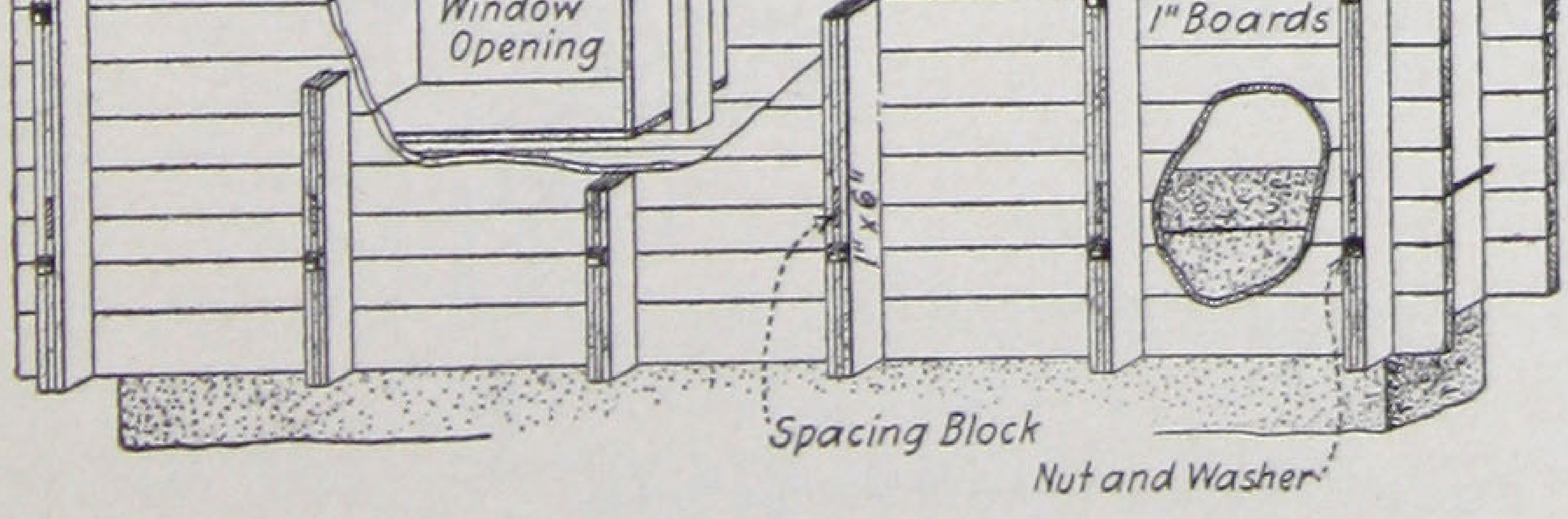



Fig. 52.
Sectional wall form for carrying wall up vertically with minimum amount of lumber.

## Column Forms

Square and octagonal column forms are generally made of wood, while round column forms are usually of steel. Columns decrease in size from the lower to the upper stories and the forms must be designed so that they can be easily reduced to allow for this.

All square columns should have the edges beveled as it is difficult to get a perfectly sharp corner, and sharp corners are easily knocked off. When an especially good appearance is desired, the corners are rounded as shown in Figure 53 "E".

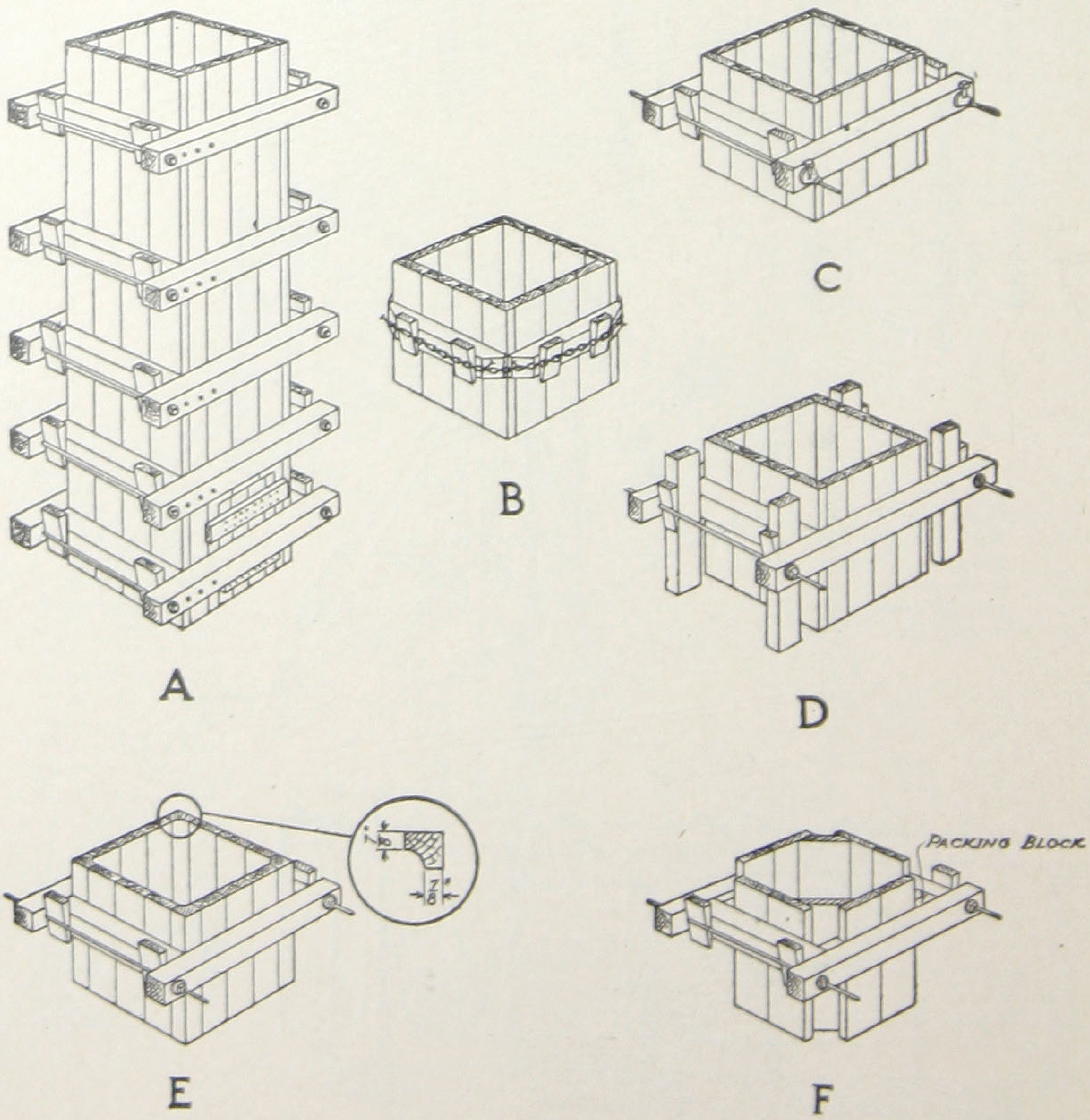



Fig. 53.—Various types of column forms.

When the forms are cleaned before concreting, the rubbish will be swept into the columns, and clean-out holes should be left in the bottom of the column forms and should be of ample size to allow thorough cleaning. The pieces of board removed for clean-out hole should be nailed to the form so that it will be ready to put back in place. In some cases it will be found easier to erect the column with three sides fastened together leaving the fourth out until the reinforcement is placed. This is usually necessary when column reinforcing is more than one story high, or when the reinforcing projects very far above the floor. Otherwise, it is preferable to assemble the column form complete and lift it into place. Exterior columns are usually built in place, one side at a time on account of the danger of the form getting away from the workmen and falling off the building.

There are several types of square column forms which have become practically standardized in building construction. The most common is that shown in Figure 53. The sheathing is $1\frac{1}{4}$-inch T. & G. D 2 S, and yokes are 4-inch x 4-inch yellow pine. The bolts should be at least $\frac{5}{8}$-inch, as smaller stock will be bent too easily by the wedges, and frequent straightening will be required.

In this column form two of the sides are made with the yokes flush with the edge of the sheathing. The other two sides have the yokes projecting at least eight inches beyond the sheathing, giving room for the driving of a wedge between the bolt and the yoke. The reduction in the size of this column is by taking off a strip along one edge of the sides which do not have the yokes projecting and by taking a strip off one of the boards on the sides having projecting yokes. Then new bolt holes are either bored in the yokes, or packing strips are placed on the yokes for the wedges to bear against. If there is a boring machine on the job, the yokes should have a series of holes bored in them before they are fastened to the column sides so that it will not be necessary for the carpenters to bore them by hand.

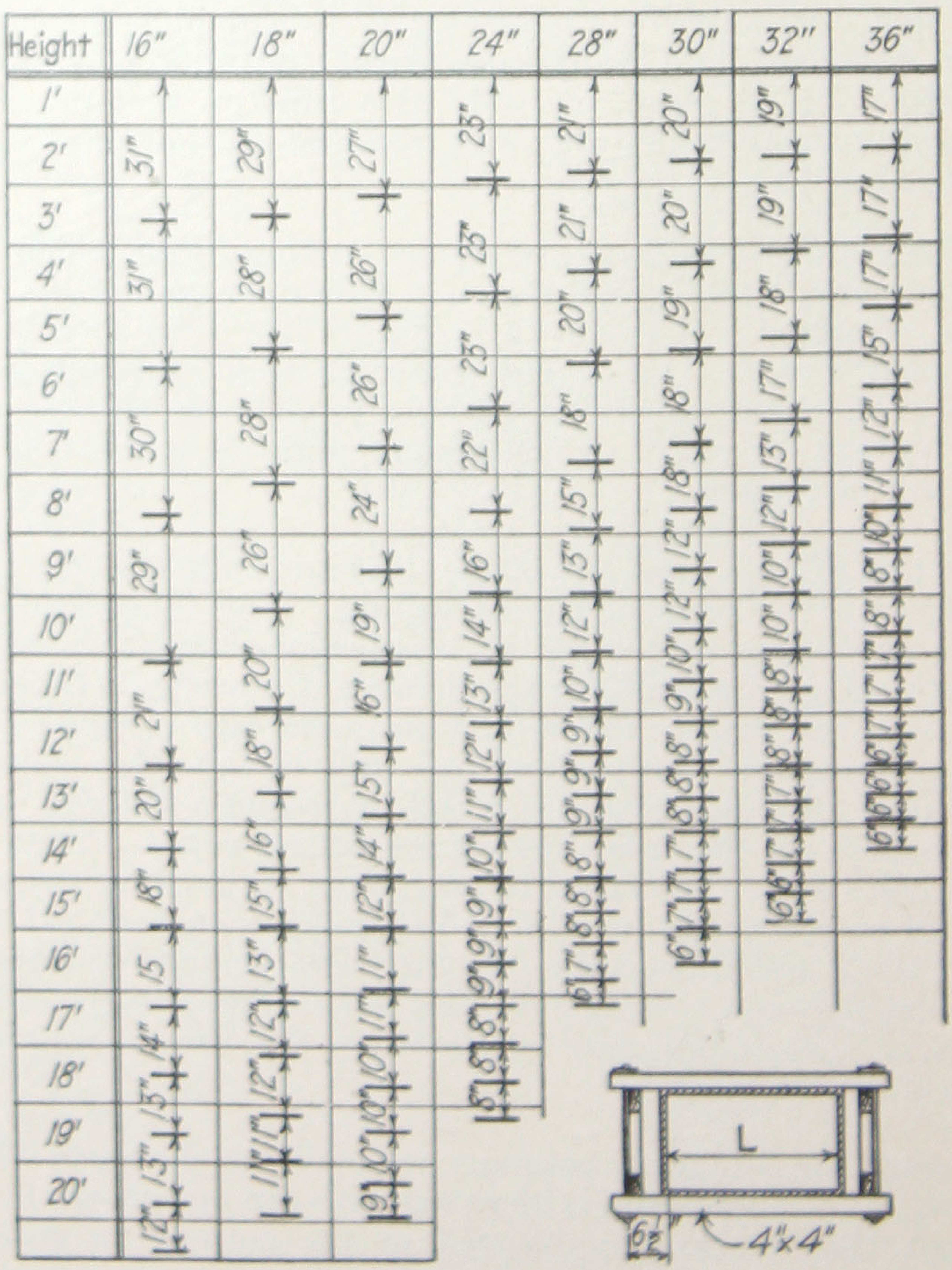
Forms for octagonal columns are made as shown in Figure 53—"F." This column is identical with the one shown in "A" except that pieces are inserted in the corners to give the

## TABLE 9

## SPACING OF YOKES FOR COLUMNS

**How to use Table.**—To find spacing of yokes for a 24″ x 18″ column 10′ high, use column headed 24″. Read up column from 10′ line, and the spacing of yokes will be found—14″ for bottom yoke, 16″ for next upper yoke, 22″ for next, and so on to top.

LARGEST DIMENSION OF COLUMN IN INCHES



column eight sides. The flare is made at the top of the column by fitting in triangular pieces of wood.

Since fresh concrete is practically liquid and over twice as heavy as water, the column form must be designed to withstand the bursting pressure of the concrete. This will make it necessary to have the yokes closer together at the bottom than at the top.

In place of bolts, rods with a malleable iron clamp fastened in place with a set screw are often used for form work. These clamps may be obtained from supply houses. The clamp is slipped over the rod and brought to a firm bearing by a device furnished by the makers of the clamps. Then the set screw in the clamp is tightened, holding the clamp in place.

In the same figure is shown a method of clamping columns by using a chain. The chain is hooked around the column as tight as possible and the slack taken up with wedges.

Table 9 gives spacing of yokes for various sizes and heights of columns. When column forms are very wide, larger yokes must be used or bolts placed through the center of the column.

In place of bolted wood yokes, many builders employ the manufactured metal column clamps of which there are a number of types available on the market. These metal clamps are designed to permit quick installation and removal and are adjustable for various sizes of column.

Exterior column forms require different treatment as one side must project over the edge of the building. Such a column is illustrated in Figure 54. The two bolts shown at the top of the form are left in the concrete with the ends projecting. To these bolts are fastened blocks to support the overhanging sides of the form. The bolts are removed later by turning out with a wrench. Stud bolts are put in the floor, when it is soft, to which blocks are attached for bracing the form. The blocks may be slotted to allow for adjustment. The brace is nailed directly to the block. In these forms the outside piece is erected first and braced and the other side placed afterward.

Round columns are usually built with steel forms and heads. These forms are usually hired for the life of a job and the

erection and stripping done by the company supplying the forms. They are used mainly in the flat slab construction. The shell is of sheetsteel held with clamps and the head is made in sections to allow for reduction.

## Forms for Beam and Girder Floor Systems

Forms for beams and girder floors vary somewhat. This variation depends upon whether the beam and girder forms are to be stripped in one piece or the sides are to be removed and the bottoms left in place until the shores are removed.

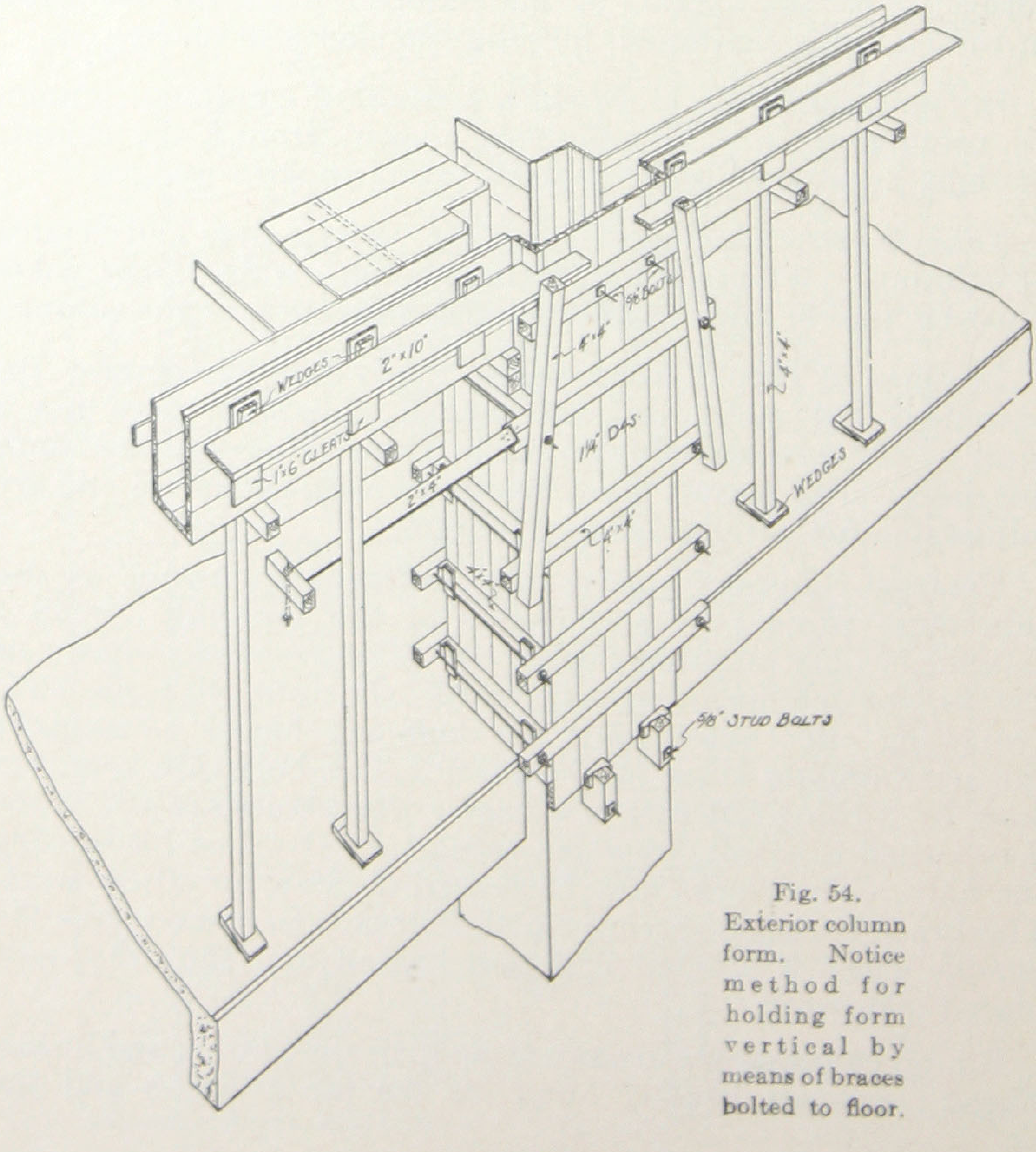
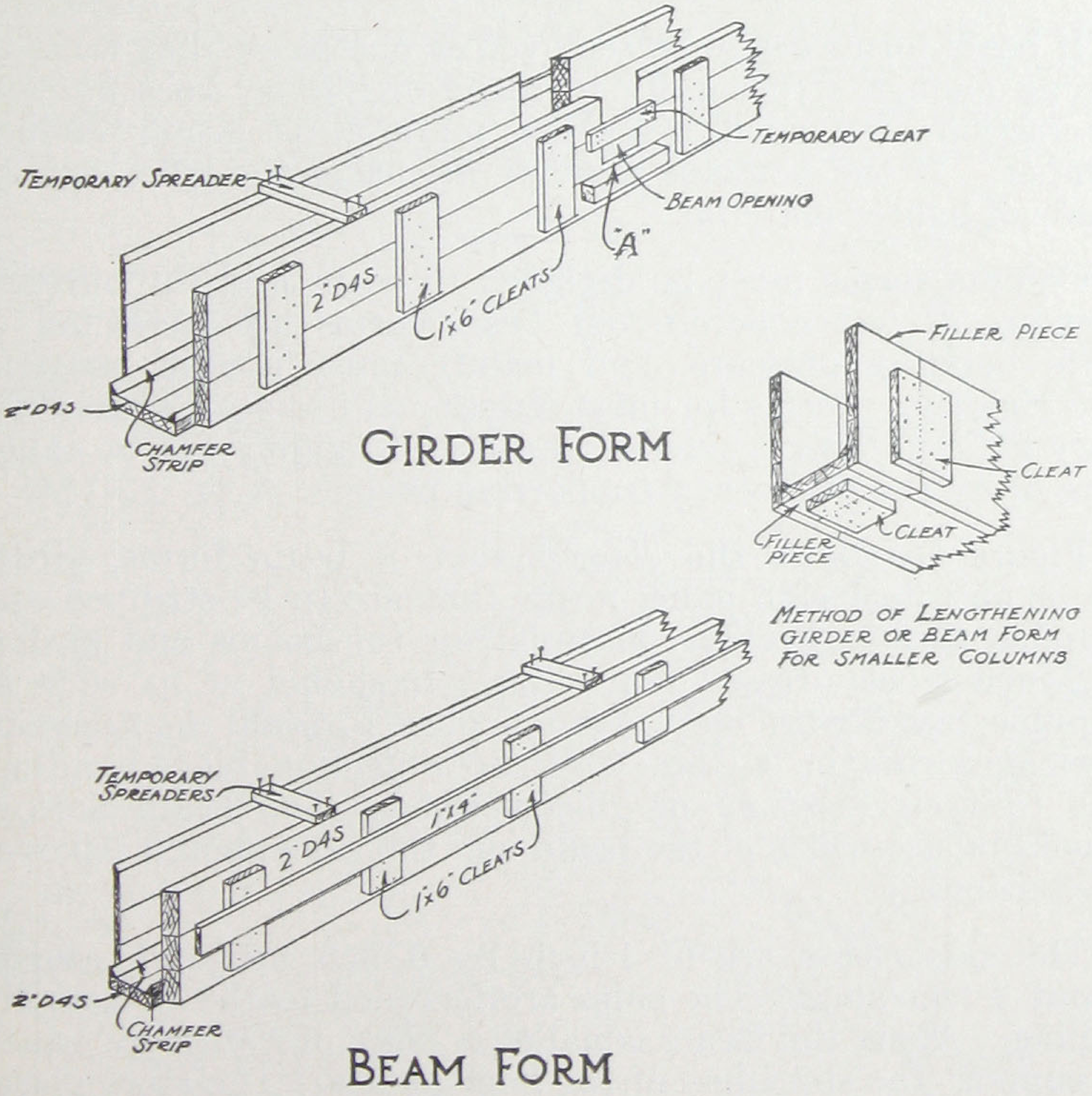



Fig. 54. Exterior column form. Notice method for holding form vertical by means of braces bolted to floor.



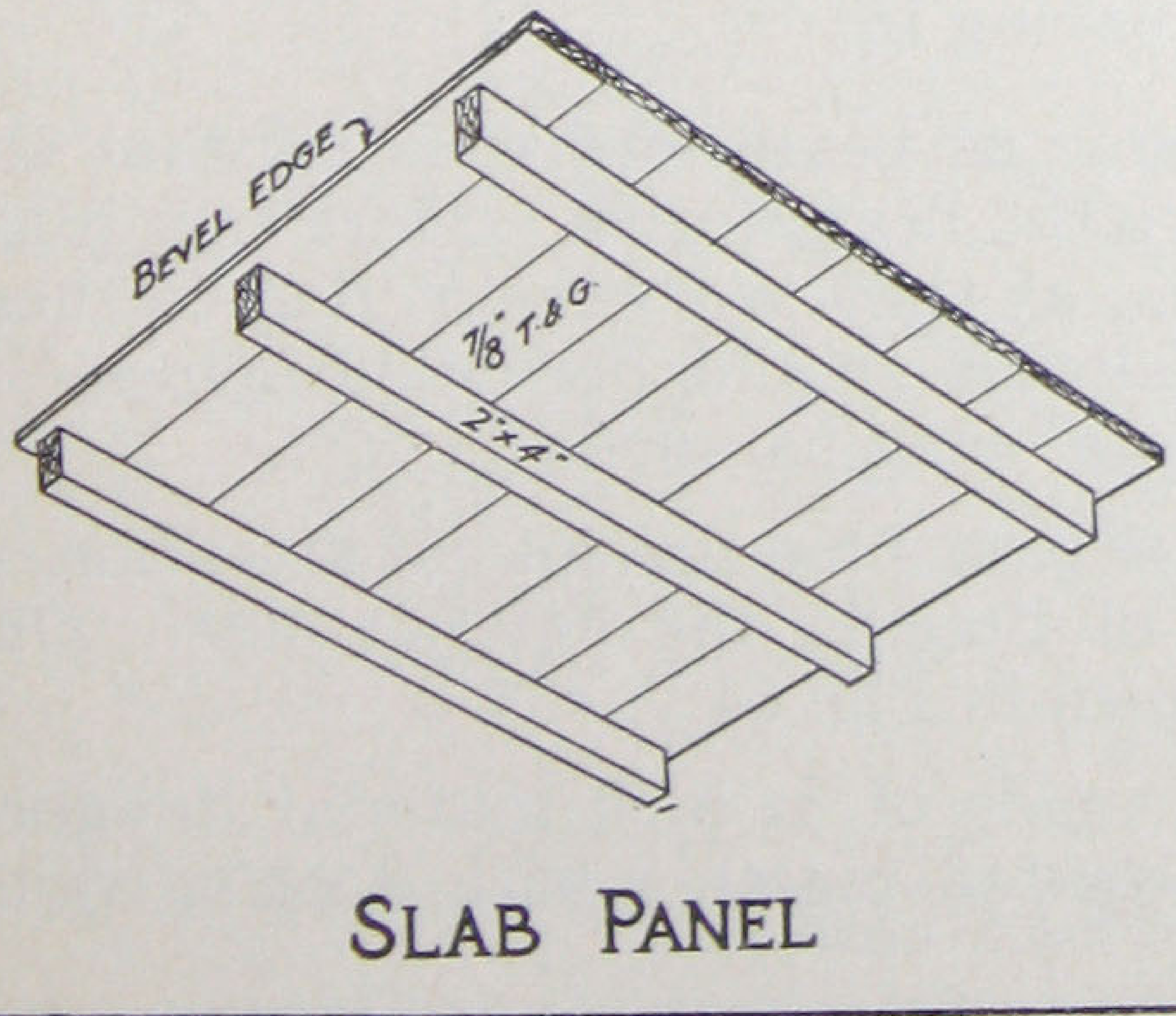




Fig. 55.—Beam and girder construction. Slab, beam and girder forms for use when the forms are removed as a unit. Figure 56 shows these forms assembled.

## Removable Beam Forms

If beam forms are to be removed as one piece, they must be strong enough structurally to stand stripping, hoisting, and re-erection. In such cases the material is usually 2-inch lumber. If the bottoms are left in place, the sides can be made of lighter material.

Column forms must be designed to withstand the bursting pressure of wet concrete but beam forms are subjected to little bursting pressure, and mainly must possess strength and rigidity. Forms for most lengths and sizes of beams will vary little in design, since strength and rigidity will be taken care of by the number of supporting posts.

Figure 55 shows the construction of beam forms, girder forms and floor slab panel forms that are to be stripped and handled as a unit. The material for the beams and girders is 2-inch stock dressed four sides. It should be as wide as possible, making the bottom in one piece to avoid the necessity of cleats across the bottom, which are objectionable in handling due to their catching on obstructions. The beam bottom should be the width of the beam and the sides should lap over the bottom.

The side cleats are of 1-inch by 6-inch material, spaced about 3 feet apart. The sides are fastened to the bottom by nailing. Along the cleats is nailed a piece of 1-inch by 4-inch to support the spreaders of the floor panels. The cross pieces shown on top are tacked on when the form is being handled to prevent the side from caving in.

Girder forms are the same as beam forms except that the sides are notched to receive the beam forms. More care must be taken in handling them, as they are weaker, due to these cuts. Temporary cleats always should be nailed across the beam opening while they are being handled.

Exterior beam and girder forms require special attention on account of the difficulty of bracing the exterior side. One method of doing this is shown in Fig. 54.

Slab panels are usually made of ⅞-inch material, tongued and grooved. These are cleated together with 2 x 4's, which also serve as spreaders.

Fig. 56 shows the assembling of the forms shown in Fig. 55. The beam and girder forms rest on blocks on the top yokes of the columns. The ends of the beam and girder bottoms are flush with the column forms. The end of the sides of the girder or beam forms is made of a piece that is loose, so that it can be easily removed to facilitate stripping. As the columns

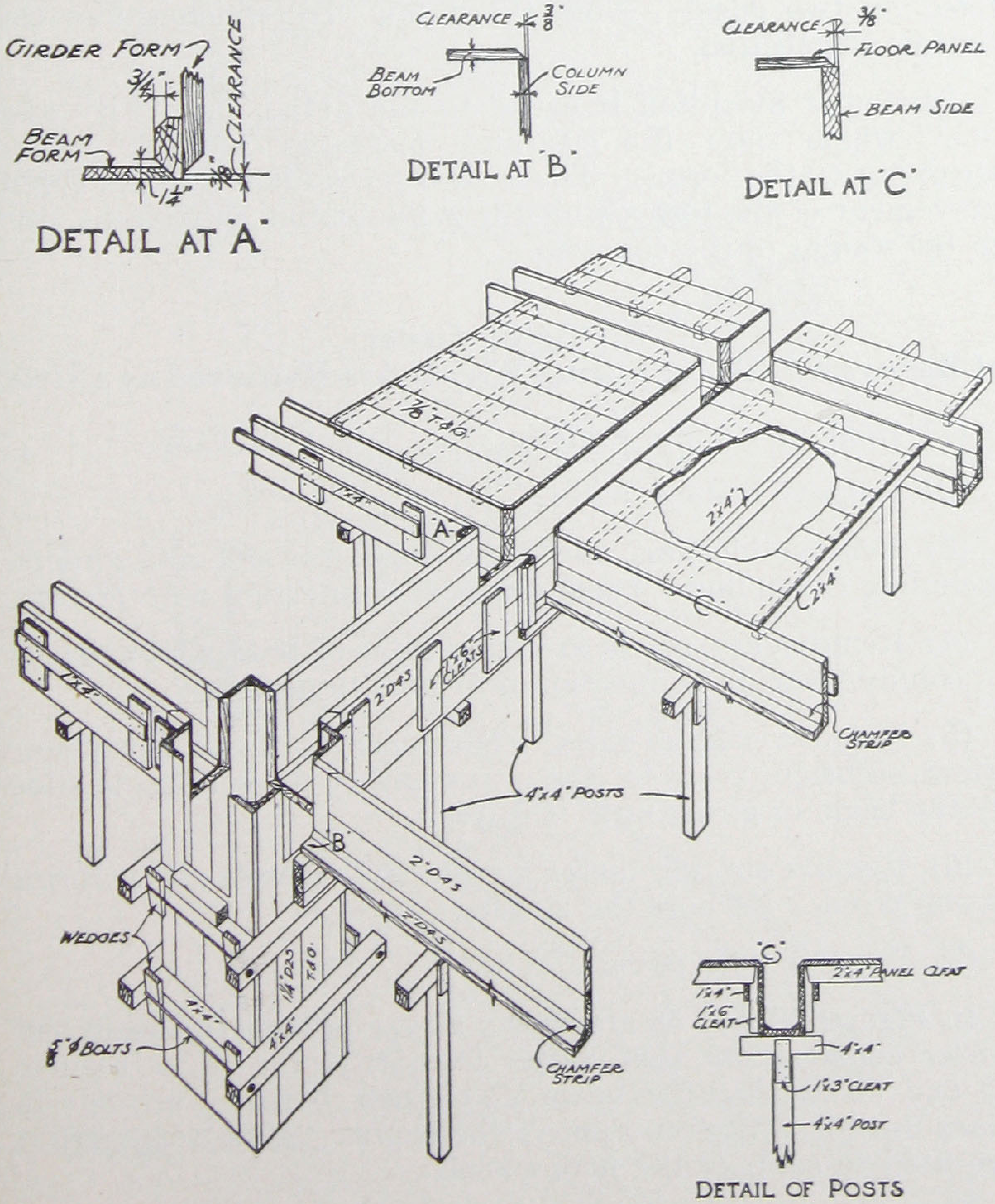



Fig. 56.—Forms for beam and girder floor system, showing forms which are to be completely removed as one unit.

grow smaller this loose piece is employed to lengthen out the beam and girder forms as shown in the detail in Fig. 55.

The connection of the beam and girder is shown in Fig. 56, point "A." The beam bottom is flush with the exterior of the girder side and rests on a cleat nailed on the girder side. The beam sides are beveled to receive a piece of 2 x 4 chamfered on two edges. Note the detail "B" which shows the bottom connection.

Particular attention is called to the detail, "A," "B" and "C," which show the clearance necessary for the proper stripping of the forms. These clearances allow for the slight movement of the forms which it is impossible to prevent, due to the weight of the concrete.

## Stripping Order of Beam and Girder Forms Which Are Removed as a Unit

(1) Remove column wedges.

(2) Remove column bolts.

(3) Remove blocking under the ends of beams and girders, including cleats under beam forms at connection with girder

(4) Remove key pieces at connections of beams and girders to columns and at connection of beams to girders.

(5) Remove column sides. The removal of the key pieces allows sufficient room for the upper end of the column to slide by the beam or girder until it is free.

(6) Remove shoring under girders and remove girder forms in one piece. Reshore the girders.

(7) Remove floor panels.

In Figures 57 and 58 are shown a type of form for beam and girder construction that varies from that shown in Figures 55 and 56 in that the beam and girder bottoms are left in place until it is time to remove the shores. Also loose purlins are used to support the floor panels.

Note also that the details of the connections of the beams, girders and columns are different.

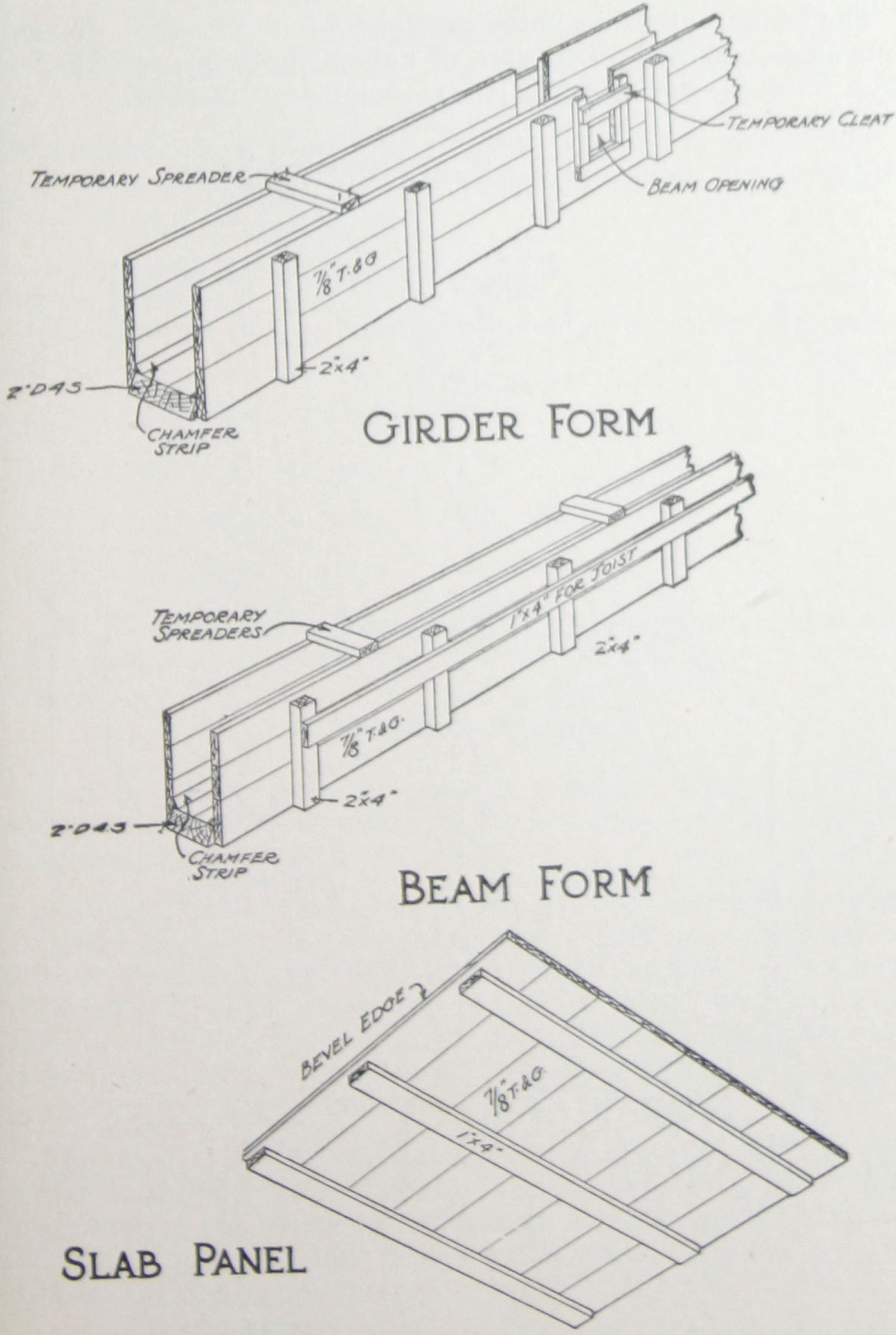



Fig. 57.—Beam and girder forms which are to be removed so that girder and beam bottoms remain in place on posts after sides are removed.

The beam and girder bottoms are of 2-inch material, dressed four sides, while the sides are of lighter material, such as ⅞-inch T. & G. sheathing.

The beams and girder sides are held tight to the bottom by continuous strips nailed to the heads of the posts.

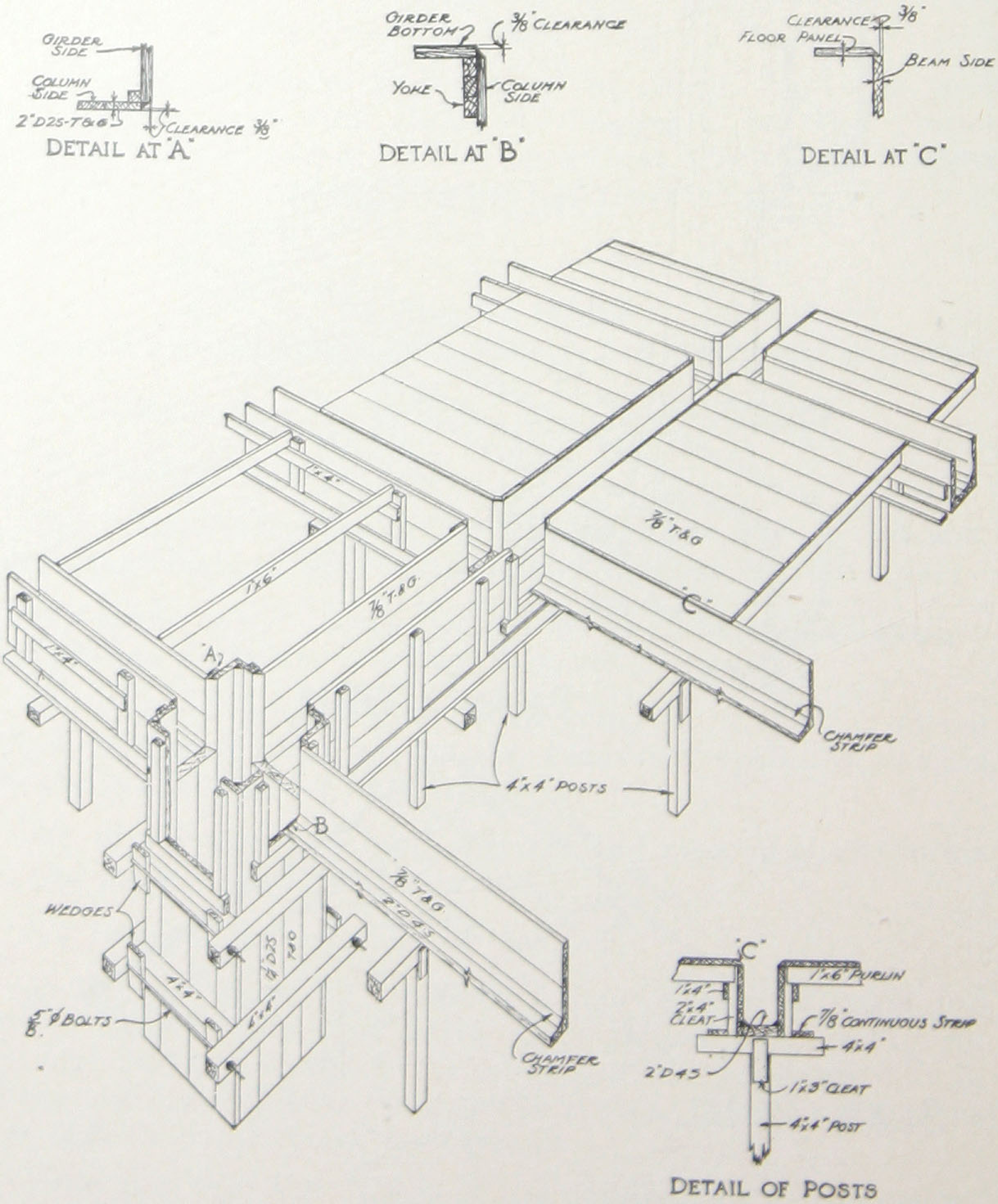



Fig. 58.—Forms for beam and girder floor assembled. See Figure 57 for details.

## Stripping Order of Beams and Girder Forms in Which Bottoms Remain in Place and Sides Are Removed

(1) Remove column wedges.

(2) Remove column bolts.

(3) Remove column sides.

(4) Remove strips holding lower edge of beam and girder sides.

(5) Remove floor panel purlins.

(6) Remove girder sides.

(7) Remove beam sides.

(8) Remove slab panels.

(9) When floor has gained sufficient strength the beam and girder bottoms are removed with the shoring posts.

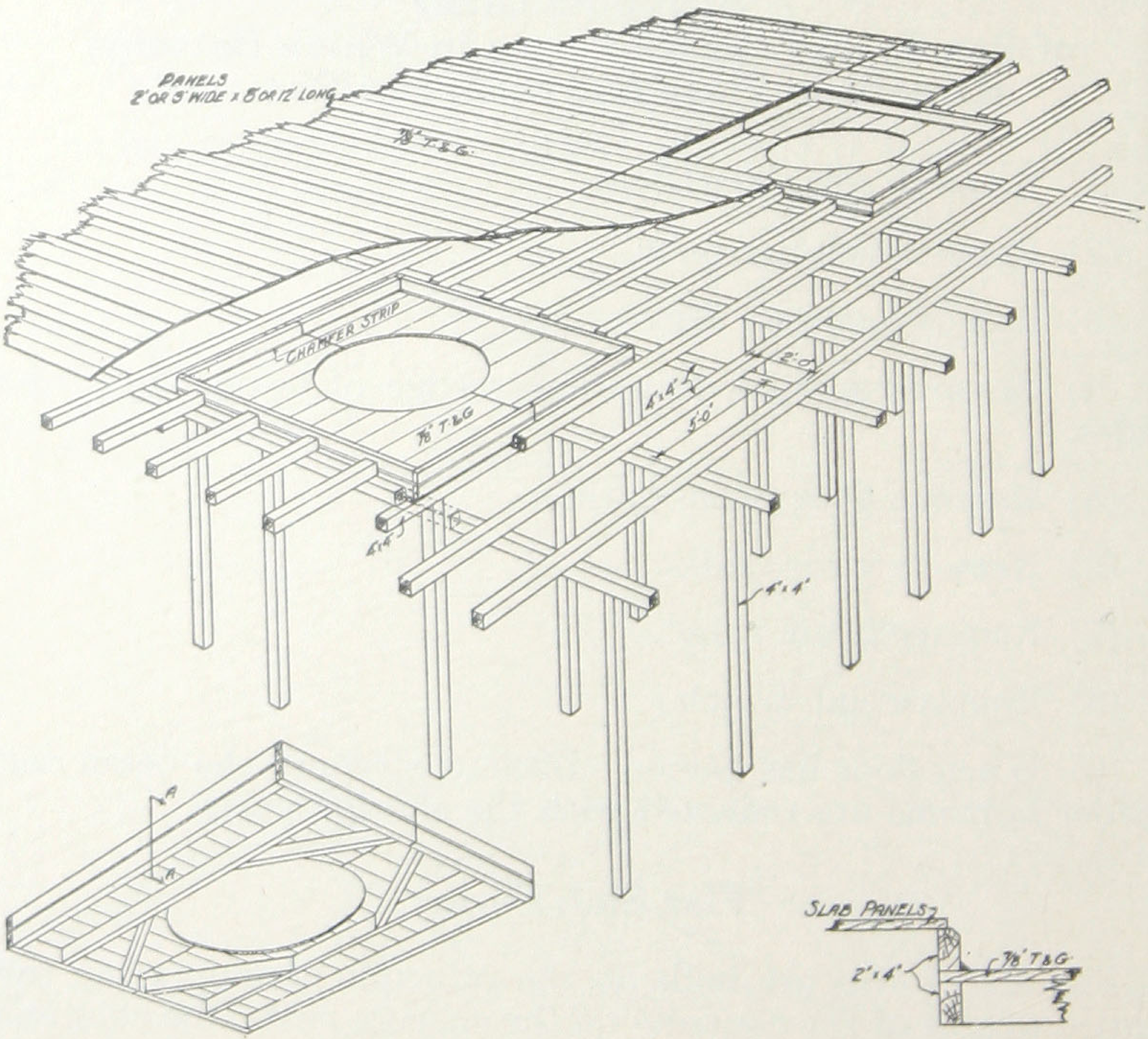
## Flat Slab Forms

Flat slab forms are built on the principle of supporting the entire weight of the concrete on the shoring posts, the columns taking none of the load.

In Fig. 59, the posts are of 4-inch x 4-inch material carrying longitudinal 4-inch x 4-inch stringers. These posts are about 5 feet apart each way. The stringers are fastened to the posts with cleats. The posts are braced in each direction with 1-inch material. On top of the stringers are laid 4-inch x 4-inch cross pieces upon which are laid the floor panels. The cross pieces and panels are not nailed to the stringers.

The forms for the depressed heads rest directly on the stringers and their construction is shown in the figure. They are made in two sections for ease in handling. The column forms are built up either in wood or steel and have no part in supporting the slab forms.

The slab panels are of 7/8-inch T. & G. material made up in sections about 5 feet long and about 2 feet wide.




BOTTOM VIEW OF DROP PANEL

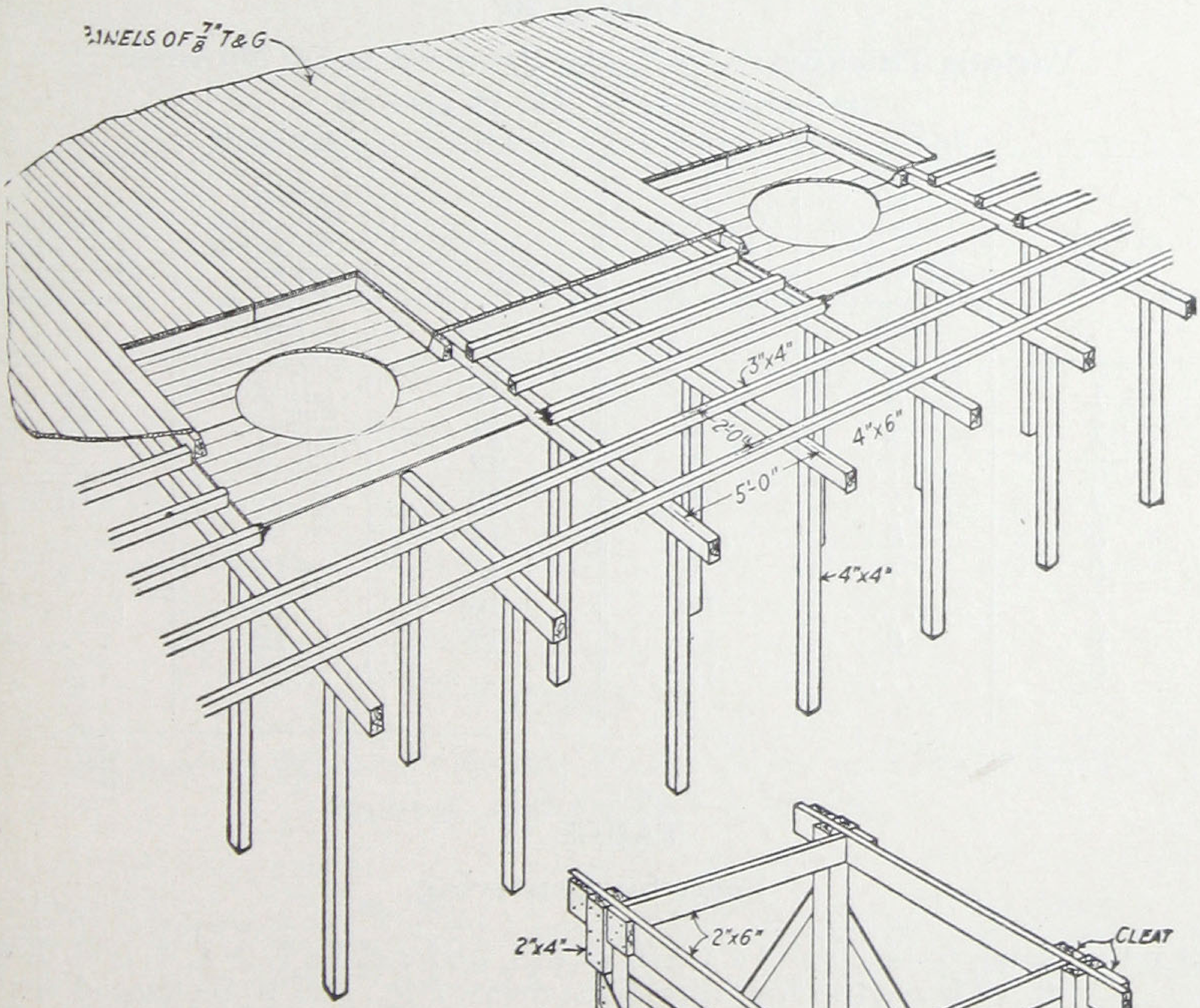
SECTION AA

Fig. 59.—Flat slab floor forms. Column heads rest directly on the stringers.

Fig. 60 shows another method of constructing flat slab forms. The depressed heads are supported on a separate framework so that it can be easily taken apart and re-erected.

The posts are 4-inch x 4-inch and carry 4-inch x 6-inch stringers. On these stringers are laid 3-inch x 4-inch cross pieces to hold the floor panels. These panels are made the length between column centers and about one-quarter the width. The side of the depressed head is formed by a piece nailed to the floor panels, allowing more leeway if columns are not exactly centered.

The tables on pages 74 and 75 give the sizes of posts, stringers and joists for flat slab forms.



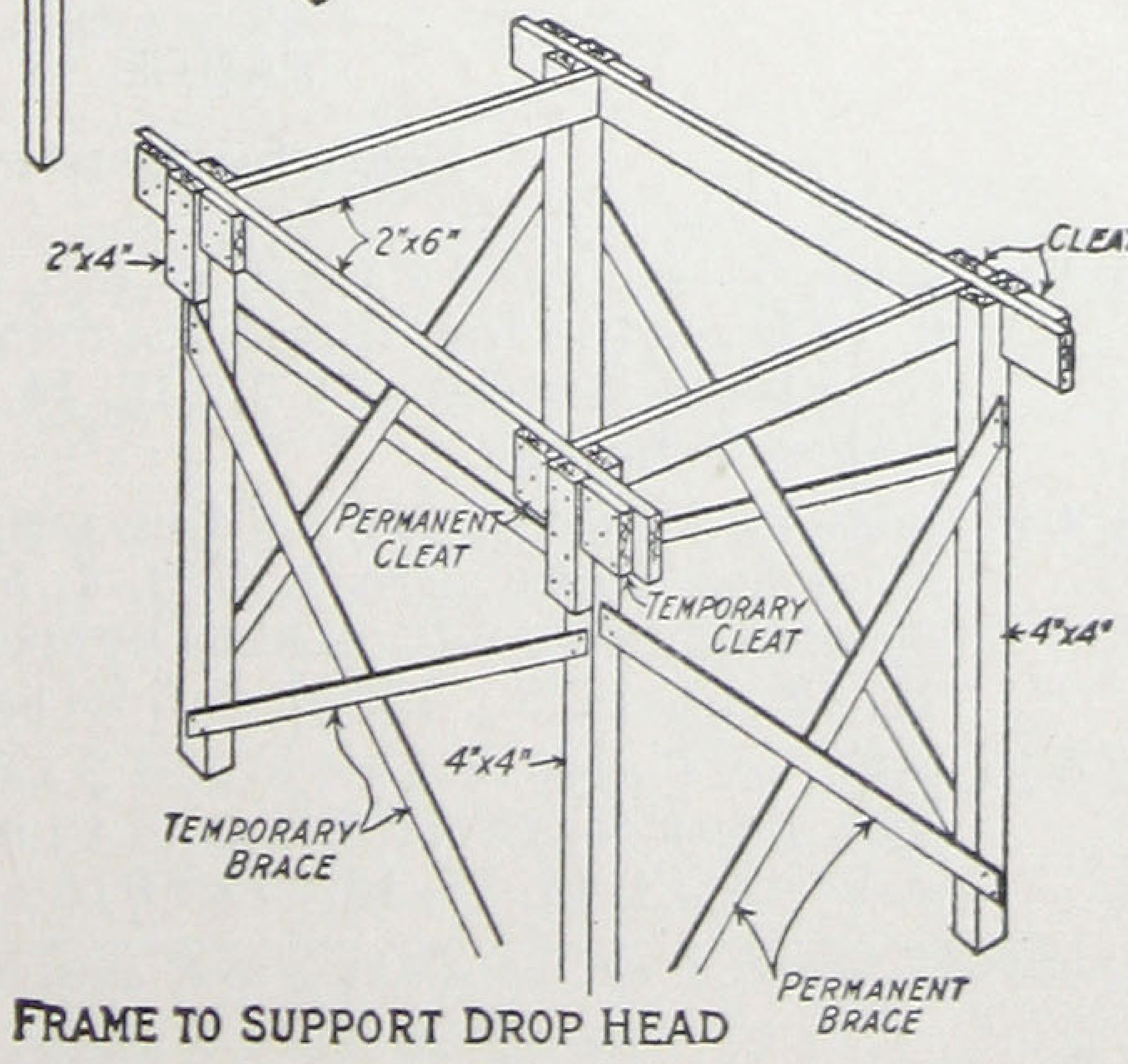




Fig. 60.—Forms for flat slab floor system in which column heads are supported on a frame or scaffold.

## Forms for Special Floor Systems

In addition to the flat-slab and slab-and-beam type of concrete floors, there are several special types involving the use of clay filler-tile and reinforced concrete. Also permanent and removable steel "dishpan" forms, etc. The methods of making forms and supports for the floor systems are not given here as details are furnished by their manufacturers.

## TABLE 10

### Various Thicknesses of Slabs Referred to by Number in Tables 11, 12, 13, 14 and 15.

| Slab No. | Slab Thickness in Inches of Solid Concrete Slab | Combination Tile and Concrete Slab | Slab No. | Slab Thickness in Inches of Solid Concrete Slab | Combination Tile and Concrete Slab |
|---|---|---|---|---|---|
| 1 | 3 | ... | 10 | 7 | 13 |
| 2 | 4 | 6 | 11 | .... | 14 |
| 3 | ... | 7 | 12 | 8 | .... |
| 4 | ... | 8 | 13 | .... | 15 |
| 5 | 5 | .... | 14 | 9 | .... |
| 6 | ... | 9 | 15 | 10 | .... |
| 7 | ... | 10 | 16 | 11 | .... |
| 8 | 6 | 11 | 17 | 12 | .... |
| 9 | ... | 12 | .... | .... | .... |

## TABLE 11

### Posts for Centering

| | |
|---|---|
| 3 x 4-in. | solid, to be spaced 4 x 6 ft. or less, under slabs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 braced in four directions every 7 ft.; and to be spaced 4 x 4 ft. or less under slabs 11, 12, 13, 14, 15, 16, 17 and 4 ft. apart under girders or beams |
| 4 x 4-in. | solid, or T-post of two 2 x 4 in. properly spiked, to be spaced 6 x 6 ft. or less under slabs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, braced in four directions every 8 ft.; and to be spaced 4 x 6 ft. or less under slabs 11, 12, 13, 14, 15, 16, 17 or 5 ft. apart under girders or beams. |
| 6 x 6-in. | solid, or T-post or 2 x 4 in and 2 x 6 in., properly spiked, braced in four directions every 8 ft. and to be spaced 6 x 6 ft. or less under slabs 12, 13, 14, 15, 16, 17 or 6 ft. apart under girders or beams. |

## TABLE 12

### Size and Spacing of Joists on 4-Foot Spans

| Slab No. | Size Inches | Spacing Inches | Slab No. | Size Inches | Spacing Inches |
|---|---|---|---|---|---|
| 1.......... | 2 x 4 | 16 | 16.......... | 2 x 6 | 21 |
| | 2 x 6 | 24 | 17.......... | 2 x 6 | 21 |
| 2 to 15 incl.. | 2 x 6 | 24 | | | |

## TABLE 13

### Size and Spacing of Joists on 6-Foot Spans

| Slab No. | Size Inches | Spacing Inches | Slab No. | Size Inches | Spacing Inches |
|---|---|---|---|---|---|
| 1, 2 | 2 x 6 | 16 | 7, 8 | 2 x 6 | 12 |
| | 2 x 8 | 24 | | 2 x 8 | 24 |
| 3 | 2 x 6 | 15 | 9, 10, 11, 12, 13 | 2 x 6 | 12 |
| | 2 x 8 | 24 | | 2 x 8 | 21 |
| 4, 5, 6 | 2 x 6 | 14 | 14, 15, 16, 17 | 2 x 8 | 21 |
| | 2 x 8 | 24 | | 2 x 10 | 18 |

## TABLE 14

### Minimum Sizes of Girders Across Posts on 4-Foot Span, Span of Joists 4 Feet or 6 Feet

| Slab No. | Size, Inches | Slab No. | Size, Inches |
|---|---|---|---|
| 1, 2 | 2 x 10, 3 x 8 or 4 x 6 | 15 | 3 x 10, 4 x 8, 6 x 6 |
| 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 | 2 x 10 or 3 x 8 | 16 | 3 x 10 or 4 x 8 |
| 14 | 2 x 10, 4 x 8 or 6 x 6 | 17 | 2 x 12, 3 x 10 or 4 x 8 |

## TABLE 15

### Minimum Sizes of Girders Across Posts on 6-Foot Span, Span of Joists 4 Feet or 6 Feet

| Slab No. | Size, Inches | Slab No. | Size, Inches |
|---|---|---|---|
| 1 | 2 x 12 or 3 x 10 | 11 | 3 x 12 |
| 2, 3 | 3 x 12, 4 x 10 or 6 x 8 | 12, 13 | 3 x 12 or 6 x 9 |
| 4, 5 | 3 x 12, 4 x 10 or 6 x 8 | 14 | 4 x 12 or 6 x 9 |
| 6, 7 | 3 x 12, 4 x 10 or 6 x 8 | 15 | 3 x 14, 4 x 12, 6 x 9 |
| 8, 9 | 3 x 12, 4 x 10 or 6 x 8 | 16 | 3 x 14, 4 x 12 |
| 10 | 2 x 14 or 3 x 12 | 17 | 3 x 14, 4 x 12 or 6 x 10 |

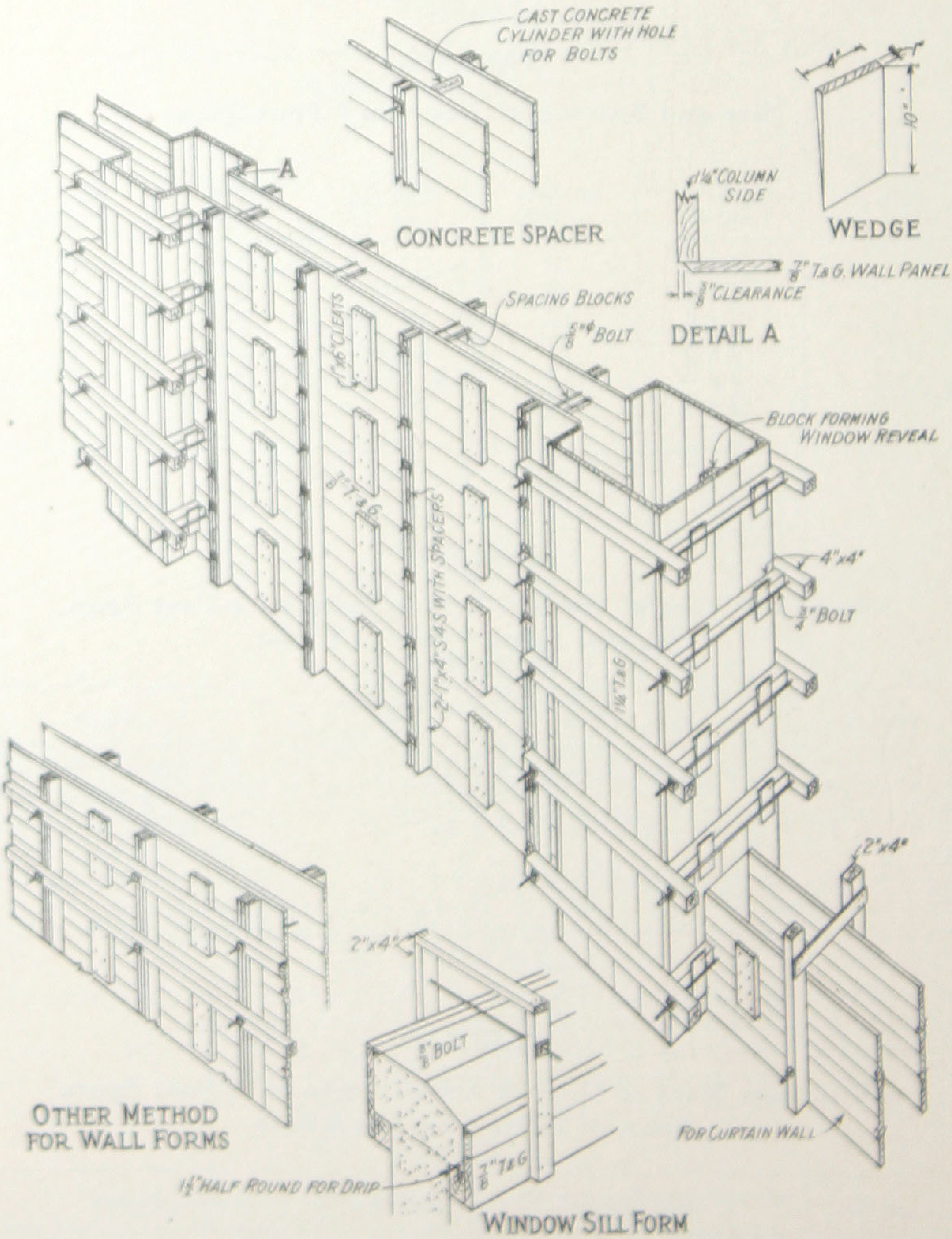



Fig. 61.—Form for curtain walls showing method of joining into column forms.

## Wall Forms

Fig. 61 shows the construction of wall forms. These are made up of convenient sized panels of ⅞-inch T. & G. material cleated together. These are tacked on standards made up

of two pieces of 1-inch x 4-inch material with 1-inch separator blocks. Through the standards and the forms are run $\frac{5}{8}$-inch bolts. The forms are kept the proper distance apart by small sticks cut to a length equal to the thickness of the wall. These sticks are knocked out as the concrete is poured. Another method of keeping the forms apart is by using pre-cast cylinders of concrete with a hole for the bolt through the center. These blocks remain in the concrete.

Various patented types of removable ties and spacers for wall forms may be purchased. The object of all these is to prevent any metal at the surface of the concrete and to eliminate any direct passage through the wall which might cause leaks in the case of tanks, swimming pools and reservoirs.

Fig. 61 also shows the method of connecting wall and column forms when they are poured at the same time and also the construction of curtain-wall forms. The small detail shows the forms for the window sills when they are poured after the walls.

Sometimes in order to give stiffness to the forms, horizontal 4 x 4's are placed against the standards shown in the sketch in the lower left hand corner of Figure 61.

## Forms for Fireproofing of Steel

Forms used in fireproofing of steel with concrete are usually much lighter than those used for structural concrete, since cinder concrete, which weighs far less than stone concrete, is generally employed for fireproofing; because the amount of concrete to be supported is less; and because there is usually no load on the concrete due to building operations.

The forms are usually 1-inch material. Instead of being supported by shores, they are hung from the steel members. This is shown in Fig. 62. Heavy wire is looped under 1 x 4 stringers, the ends of the wire being bent over the flange of the I-beam. On these stringers rest the beam forms. The purlins for the slab forms rest on "L" shaped members made by nailing two boards together along the edge. The forms are released by cutting the wire under the stringer.

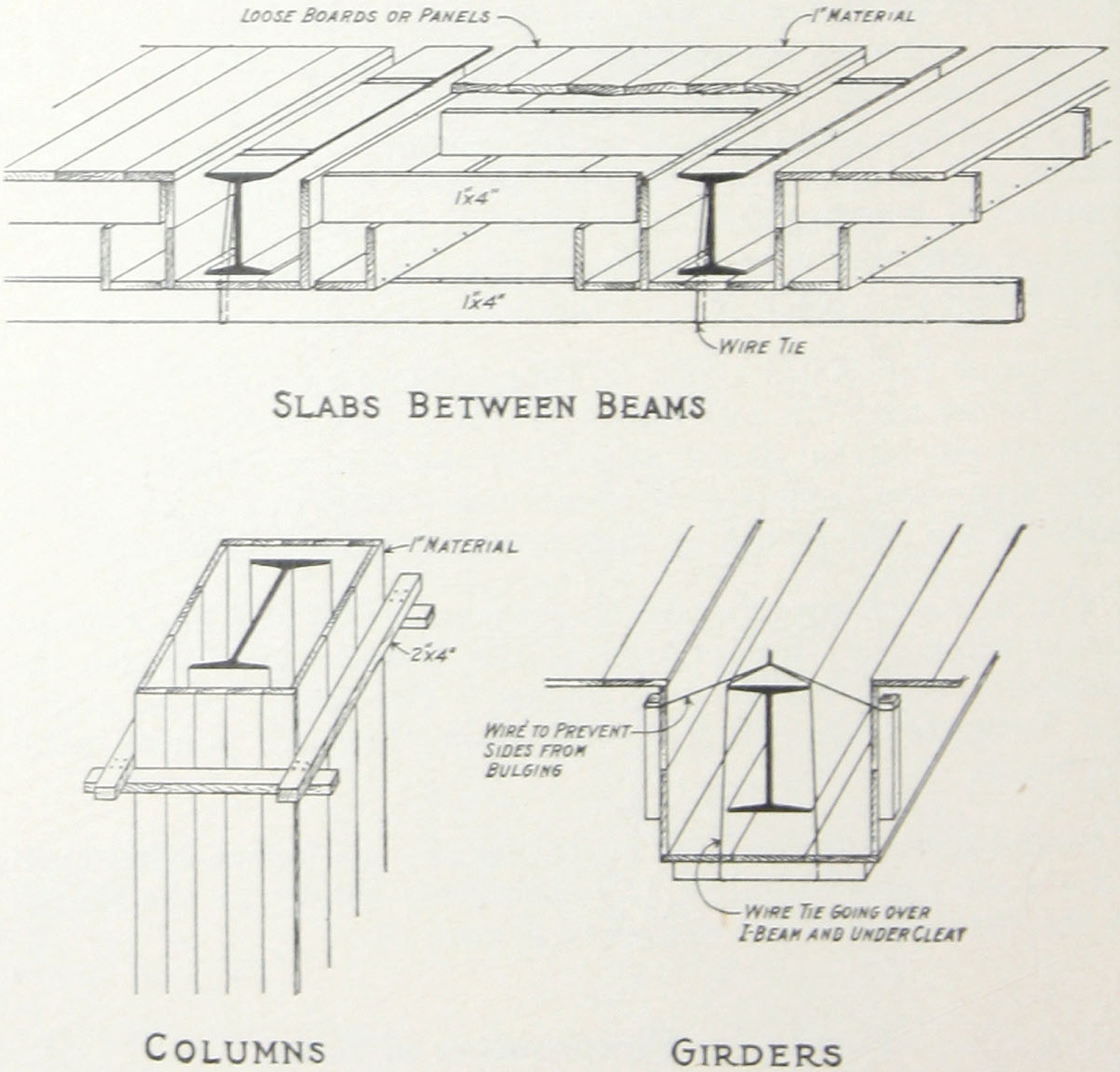



Fig. 62.—Forms for use where concrete is employed to fireproof structural steel members.

The forms for fireproofing columns are shown in Fig. 62, and usually have 2-inch x 4-inch yokes, or the sides are nailed together at the edges.

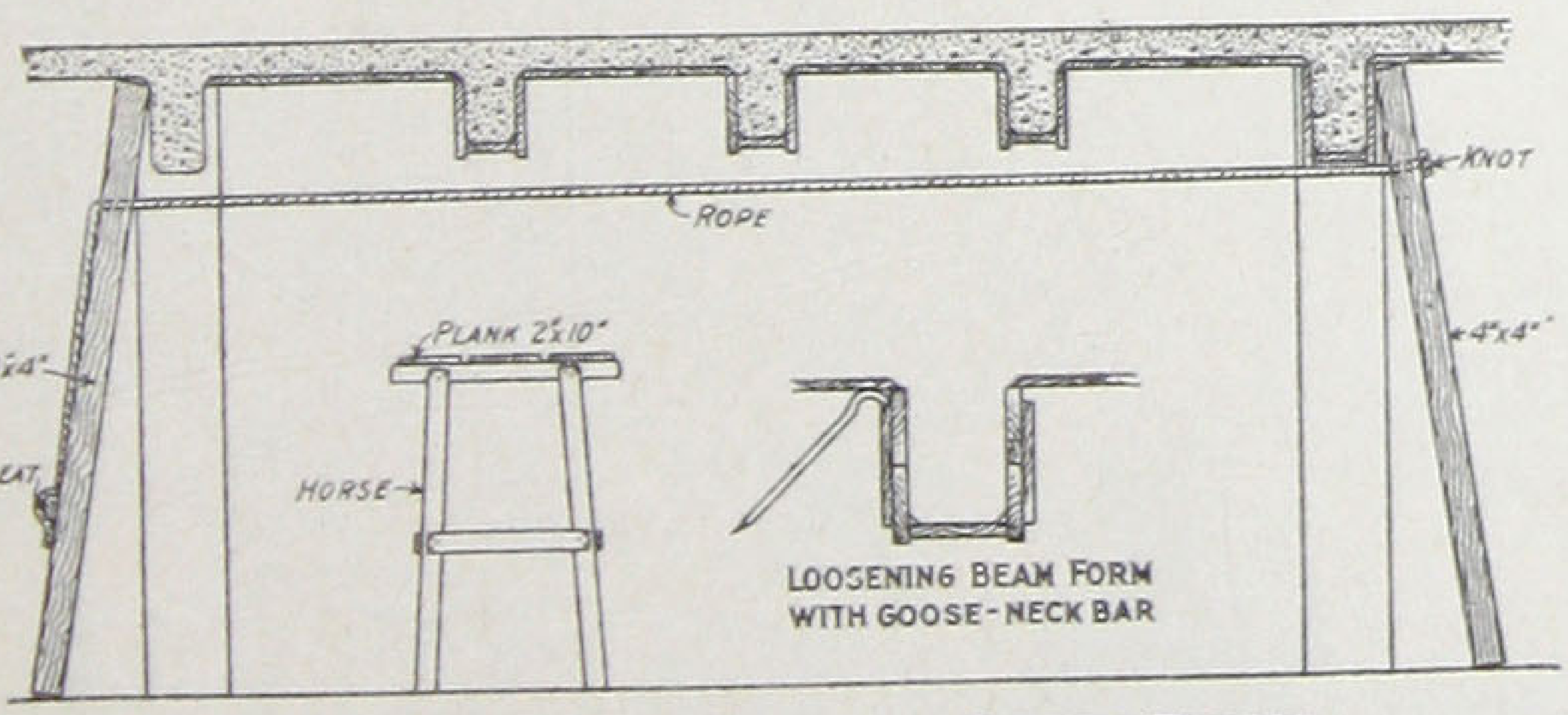
### Stripping of Forms

Forms must be constructed so that they can be removed without injury to the concrete and, if they are to be used more than once, without injury to themselves. Particular care has been taken in designing the forms here shown so that the foregoing is possible.

The order in which the stripping of the forms should be done for beam and girder construction is given on page 68. The column sides are first removed. After removing the blocking between the column yokes and the beam bottoms, and the key pieces between the column sides and beam sides, of the type shown in Fig. 58, the bottom of the column form should be pried loose. After being moved out for 6 or 8 inches, the column side will come free at point "B" and the space occupied by the key piece will give room enough to allow the column side to be removed. In the type shown in Fig. 56, the column sides will slide by the beam forms without the removal of the key pieces.

The next step is to remove the purlins unless they form the panel cleats. This can best be done from a scaffold on horses.

It is then necessary to remove the girder forms. As these are heavy, the best method is shown in Fig. 63. This very simple rig consists of 4 pieces of 4-inch x 4-inch used in pairs. The 4-inch x 4-inch sticks are cut just a little longer than the




STRIPPING RIG FOR BEAM AND GIRDER FORMS

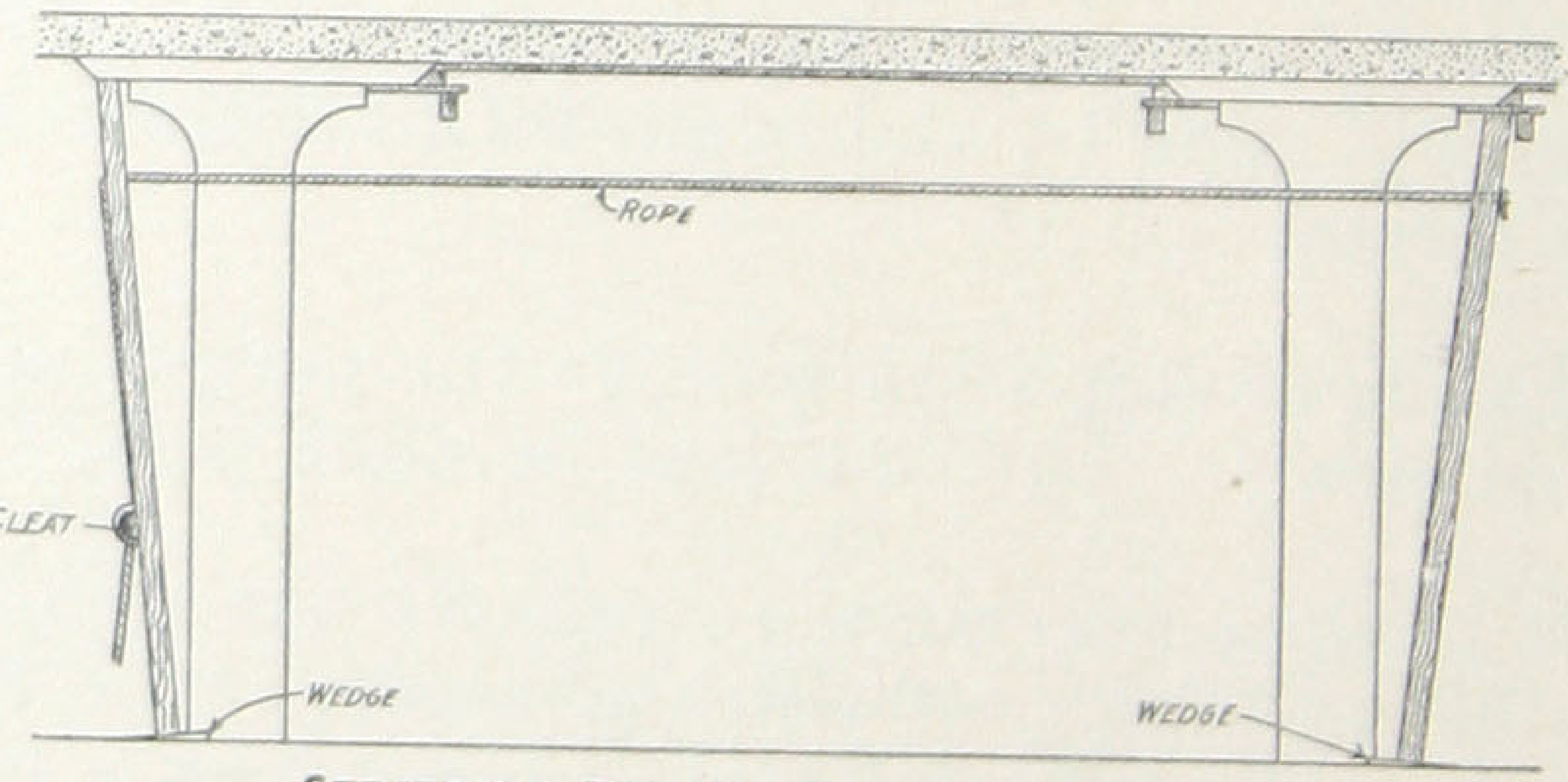
Fig. 63.—Stripping rig for holding slab and girder forms when they are stripped from concrete.

height between the floor and ceiling slab. Through the upper end, at a point just below the girder forms, are bored holes to take a 1-inch rope. This is knotted against one of the sticks to which is nailed a cleat. The sticks are then erected with the bottoms wedged tight as shown in Fig. 63, and the rope pulled taut and fastened to the cleat. The girder shores are then removed. If the girder form sticks, it can be readily loosened by using goose neck bars as shown in Fig. 63. The girder forms are then dropped on to the ropes and lowered

to the floor by releasing the ropes from around the cleats. The girder shores are then replaced.

The same operation is used in stripping the beam and slab forms. The same general method is used in stripping beam and girder forms where the beam and girder bottoms are left in place. In this case, the continuous strip on top of the posts is first removed and then the beam and girder sides are pried loose, falling on to the ropes.

Fig. 64.—Stripping rig employed for supporting flat slab forms when they are stripped from concrete.




STRIPPING RIG FOR FLAT SLAB FORMS

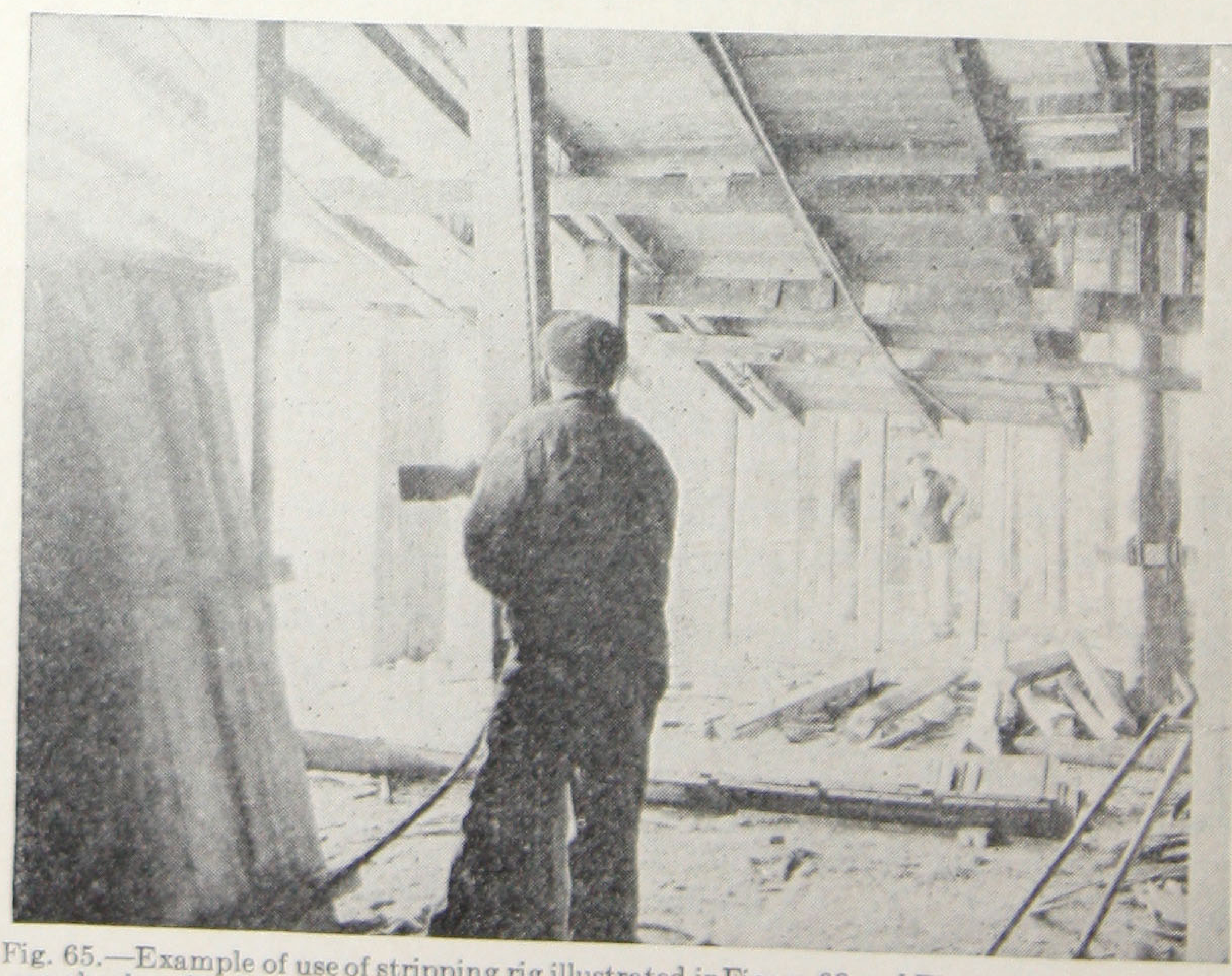


Fig. 65.—Example of use of stripping rig illustrated inFigure 63 and Figure 64. Notice workmen slowly releasing rope and allowing the floor form to descend from its original position.

A similar rig is used for stripping flat slab forms as shown in Fig. 64. The sticks are cut a little longer than the story height with the result that any weight on the ropes serves to wedge the sticks together. In stripping the flat slab forms the permanent shores should be placed before the form shores are removed. In order that the panels can be removed when the permanent shores are in place, a small section of the panel is left loose along the joint where the shore is to go. Then the stripping rig is erected and the shores, longitudinal and cross stringers removed and the floor slabs pulled down.

In the type of forms shown in Fig. 59, the forms for the depressed heads are removed at the same time as the slab panels, while in Fig. 60, the scaffold holding the depressed head forms is removed first.

The main features of this stripping rig is that the forms are not injured in stripping and if, when removing the shores some beam or slab panel should fall, the workmen will not be injured, as the forms will be caught by the ropes.

## Circular Forms

Circular forms are of two types: movable forms, and stationary forms.

In making the movable forms, pieces of lumber are cut and nailed together as shown in Fig. 66 and then lined with galvanized iron so as to form a smooth, even surface. The forms are generally laid out on a floor, or level piece of ground, by means of a stake at the center and the use of a compass stick with holes at each end, the distance between being equal to the radius of the circle. The hole at one end is used for fastening the stick to the stake and the hole at the other end is for a pencil to mark the circle.

In constructing tall tanks or silos, the forms are wedged in place, and filled with concrete. When the concrete is sufficiently hard the wedges are loosened and the forms raised,

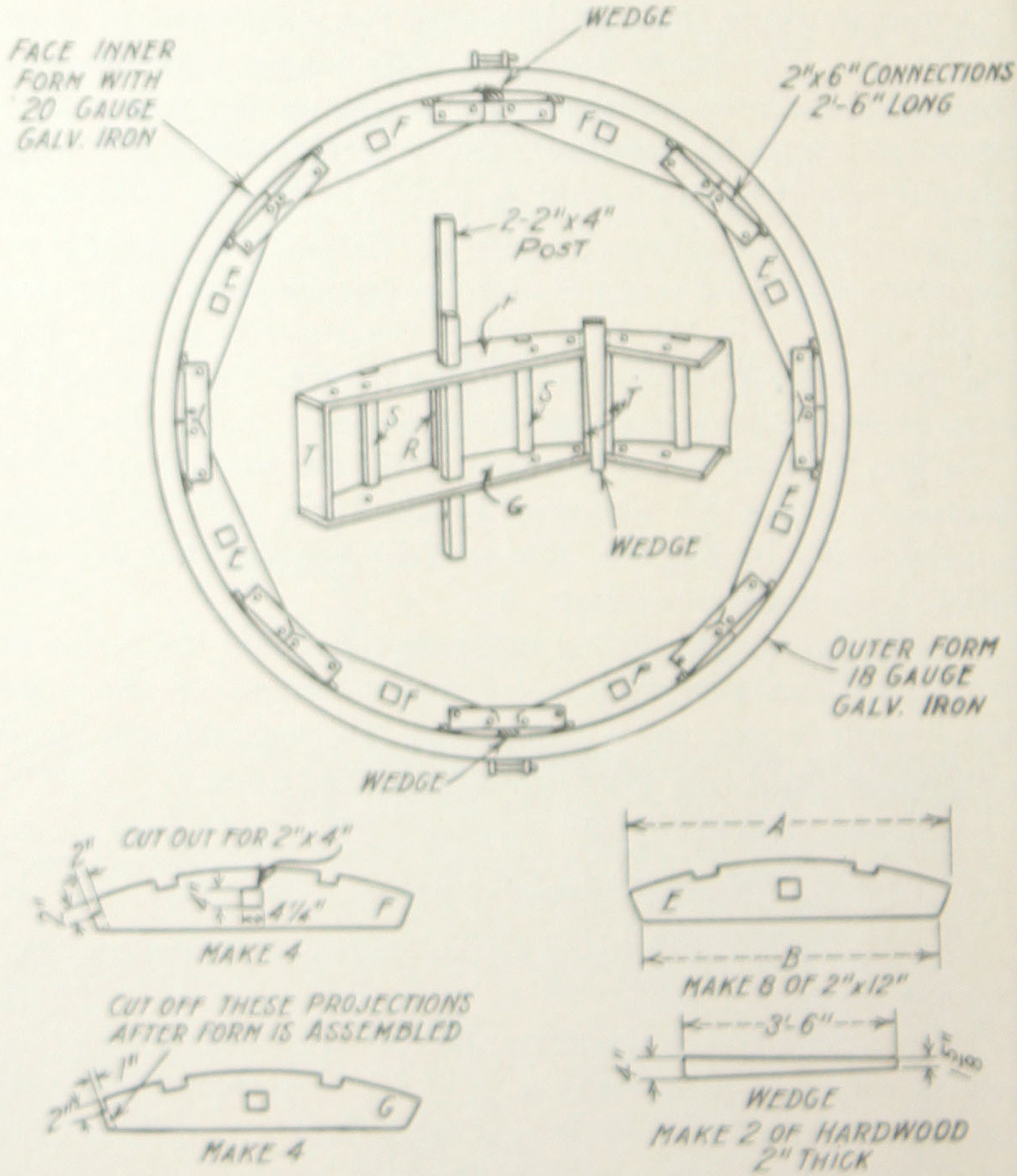



Fig. 66.—Details of circular form. For list of materials see Table 16.

guided by the uprights which consist of two 2 x 4's extending through the square holes in the horizontal pieces. The forms are wedged in place and again filled. Movable forms work very advantageously on certain types of work, such as silos and grain tanks. If the builder is doing very much tank, elevator or silo construction, he usually finds a set of steel forms to represent economy.

## TABLE 16
### Sizes and Quantities for Circular Forms of Various Diameters

| INNER FORM | | | | | OUTER FORM |
|---|---|---|---|---|---|
| Inside Diam. | Number of Sections in Inner Form | Length A | Length B | 20-Gauge Gal. Iron 36 In. Wide, Length of Each Piece | 18-Gauge Gal. Iron 36 In. Wide, 2 Pcs. Length of Each Piece |
| 10 ft. | 6 | 5′- 0″ | 4′- 7½″ | 5′-2¾″ | 18′- 3″ |
| 12 ft. | 8 | 4′- 6¾″ | 4′- 1½″ | 4′-8½″ | 21′- 5″ |
| 14 ft. | 8 | 5′- 4″ | 4′-11½″ | 5′-6″ | 24′- 7″ |
| 16 ft. | 8 | 6′- 1″ | 5′- 9½″ | 6′-3″ | 27′- 9″ |
| 18 ft. | 8 | 6′-10½″ | 6′- 7½″ | 7′-0¾″ | 30′-10½″ |
| 20 ft. | 10 | 6′- 2″ | 5′-10″ | 6′-3″ | 34′- 0″ |

### Material for 14-Foot Silo Form

5 pieces 2x12x16 feet, for ribs.
1 piece 2x12x 6 feet, for ribs.
4 pieces 2x 6x12 feet, for studding.
6 pieces 2x 4x12 feet, for studding.
4 pieces 2x 6x10 feet, for connections.
3 pieces 2x6x8 feet, for continuous door form.
2 pieces 2x2x8 feet, for continuous door form.
64 pieces ½x4½ in. carriage bolts.
2 pieces 18 gauge galvanized iron 3 feet wide, 24 feet 7 inches long.
8 pieces 20 gauge galvanized iron 3 feet wide, 5 feet 6 inches long.

Fig. 67.—Inside section of circular form in place. Outside form will be used above ground level.

## Greasing Forms and Moulds for Concrete Construction

The object of greasing wood forms is twofold—first to waterproof the wood to prevent it from absorbing the water in the concrete, causing swelling and warping; and, secondly, to leave a thin skin of the grease on the surface of the forms to prevent concrete from entering the pores of the wood and adhering to it.

Forms should be thoroughly swept before the reinforcing is placed and kept clean until the concrete is poured. If

Fig. 68.—Greasing form-panels before placing in position.

there is dirt or sawdust on the wood the grease will cover this and not coat the surface of the wood.

The most satisfactory greases are the mineral oils and paraffins. Crude or fuel oil is the cheapest and is satisfactory. It is, however, too thin, except in cold weather, and is best mixed with petroleum grease such as refined vaseline. The crude or fuel oil is mixed with this grease in the proportion of one part of grease to three or more parts of oil. The proportion will vary according to temperature, more grease being re-

quired in warmer weather. Other materials used are asphalt paints, varnish, and boiled linseed oil. For metal forms the cheapest and best grease is plain crude or fuel oil without the addition of the heavier greases.

## TABLE 17

### Table of Board Feet in Various Sizes and Lengths of Lumber For Use in Estimating Forms and other Timber Work

| Size of Timber in Inches | LENGTH OF PIECE IN FEET | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 1 x 2 | 1⅔ | 2 | 2⅓ | 2⅔ | 3 | 3⅓ | 3⅔ | 4 |
| 1 x 3 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 5½ | 6 |
| 1 x 4 | 3⅓ | 4 | 4⅔ | 5⅓ | 6 | 6⅔ | 7⅓ | 8 |
| 1 x 5 | 4⅙ | 5 | 5⅚ | 6⅔ | 7½ | 8⅓ | 9⅙ | 10 |
| 1 x 6 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 x 8 | 6⅔ | 8 | 9⅓ | 10⅔ | 12 | 13⅓ | 14⅔ | 16 |
| 1 x 10 | 8⅓ | 10 | 11⅔ | 13⅓ | 15 | 16⅔ | 18⅓ | 20 |
| 1 x 12 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 1 x 14 | 11⅔ | 14 | 16⅓ | 18⅔ | 21 | 23⅓ | 25⅔ | 28 |
| 1 x 16 | 13⅓ | 16 | 18⅔ | 21⅓ | 24 | 26⅔ | 29⅓ | 32 |
| 1 x 20 | 16⅔ | 20 | 23⅓ | 26⅔ | 30 | 33⅓ | 36⅔ | 40 |
| 1½ x 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1½ x 6 | 7½ | 9 | 10½ | 12 | 13½ | 15 | 16½ | 18 |
| 1½ x 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 1½ x 10 | 12½ | 15 | 17½ | 20 | 22½ | 25 | 27½ | 30 |
| 1½ x 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 |
| 2 x 4 | 6⅔ | 8 | 9⅓ | 10⅔ | 12 | 13⅓ | 14⅔ | 16 |
| 2 x 6 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 2 x 8 | 13⅓ | 16 | 18⅔ | 21⅓ | 24 | 26⅔ | 29⅓ | 32 |
| 2 x 10 | 16⅔ | 20 | 23⅓ | 26⅔ | 30 | 33⅓ | 36⅔ | 40 |
| 2 x 12 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | 48 |
| 2 x 14 | 23⅓ | 28 | 32⅔ | 37⅓ | 42 | 46⅔ | 51⅓ | 56 |
| 2 x 16 | 26⅔ | 32 | 37½ | 42⅔ | 48 | 53⅓ | 58⅔ | 64 |
| 2½ x 12 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| 2½ x 14 | 29⅙ | 35 | 40⅚ | 46⅔ | 52½ | 58⅓ | 64⅙ | 70 |
| 2½ x 16 | 33⅓ | 40 | 46⅔ | 53⅓ | 60 | 66⅔ | 73⅓ | 80 |
| 3 x 6 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 |
| 3 x 8 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | 48 |
| 3 x 10 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| 3 x 12 | 30 | 36 | 42 | 48 | 54 | 60 | 66 | 72 |
| 3 x 14 | 35 | 42 | 49 | 56 | 63 | 70 | 77 | 84 |
| 3 x 16 | 40 | 48 | 56 | 64 | 72 | 80 | 88 | 96 |
| 4 x 4 | 13⅓ | 16 | 18⅔ | 21⅓ | 24 | 26⅔ | 29⅓ | 32 |
| 4 x 6 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | 48 |
| 4 x 8 | 26⅔ | 32 | 37⅓ | 42⅔ | 48 | 53⅓ | 58⅔ | 64 |
| 4 x 10 | 33⅓ | 40 | 46⅔ | 53⅓ | 60 | 66⅔ | 73⅓ | 80 |
| 4 x 12 | 40 | 48 | 56 | 64 | 72 | 80 | 88 | 96 |
| 4 x 14 | 46⅔ | 56 | 65⅓ | 74⅔ | 84 | 93⅓ | 102⅔ | 112 |
| 6 x 6 | 30 | 36 | 42 | 48 | 54 | 60 | 66 | 72 |
| 6 x 8 | 40 | 48 | 56 | 64 | 72 | 80 | 88 | 96 |
| 6 x 10 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
| 6 x 12 | 60 | 72 | 84 | 96 | 108 | 120 | 132 | 144 |
| 6 x 14 | 70 | 84 | 98 | 112 | 126 | 140 | 154 | 168 |
| 6 x 16 | 80 | 96 | 112 | 128 | 144 | 160 | 176 | 192 |
| 8 x 8 | 53⅓ | 64 | 74⅔ | 85⅓ | 96 | 106⅔ | 117⅓ | 128 |
| 8 x 10 | 66⅔ | 80 | 93⅓ | 106⅔ | 120 | 133⅓ | 146⅔ | 160 |
| 8 x 12 | 80 | 96 | 112 | 128 | 144 | 160 | 176 | 192 |

Figures given are Board Feet. Lumber is usually priced by the Thousand Board Feet. A piece 1 inch thick, 12 inches wide and 1 foot long, constitutes 1 foot Board Measure.

# CHAPTER IV.

# CONSTRUCTION

## REINFORCED CONCRETE BUILDING CONSTRUCTION

A reinforced concrete building is monolithic; the foundations, columns, walls and floors are constructed in one solid unit.

There are many different types of foundations, footings, floors and columns in concrete building construction. It is not necessary to understand all the details of each, but it is essential from the standpoint of construction to have a knowledge of the principles involved.

While this chapter covers small structures particularly, the principles involved will be found useful in reinforced concrete construction generally.

The construction of a reinforced concrete building naturally resolves itself into six divisions:

(1) Foundations and footings.

(2) Floors.

(3) Columns.

(4) Roof.

(5) Walls and partitions.

(6) Stairs, elevator shafts, etc.

These six steps, however, have divisions which must be given special consideration for their economical execution, such as:

(1) Form construction, pages 54 to 81.

(2) Bending and placing of reinforcement, pages 46 to 53.

(3) Mixing and placing concrete, pages 15 to 26.

## Foundations

Concrete is the material generally employed for all foundation work. It adapts itself to any structural conditions such as irregularity of the bed. It is convenient, strong, durable and reasonable in cost. The same general principles of construction govern in foundation walls whether for large or small buildings.

## Forms

The building of forms is shown on page 58. For ordinary trench walls where the ground is solid and firm, forms are commonly built above the ground only, the trench being made just the width of the wall desired, Fig. 51, page 59. It is a good plan to lay 2″ x 10″ planks flat on the ground along the edge to prevent the earth from being broken off and knocked into the excavation. Sometimes tarred paper or burlap is hung on the side opposite that from which the concrete is poured so as to protect the earth. In the case of cellar walls or basement for buildings when the earth is sufficiently solid and firm to act in place of a form on the outer side, inside forms only are required. Fig. 48, page 58. When the earth is soft, crumbling or yielding, forms are erected on both sides, Fig. 49, page 58.

## Construction

Foundation walls are always carried below the frost line, which in southern states is at least two feet below ground level and four feet in northern states. The depth of the foundations also depends upon the character of the soil and sufficient depth must be reached to insure firm, unyielding earth, or sufficient width of foundation must be provided so as to make sure that there will be no settlement. It is, therefore, common practice to have a spread footing for the wall when it is built on soft earth. In addition to having the spread footing, the concrete wall may be reinforced at the lower edge so as to bridge over soft spots.

When building concrete basement walls and footings it is generally necessary to provide some means of fastening the superstructure to the foundation. This can easily be done by embedding bolts, head down, in the concrete.

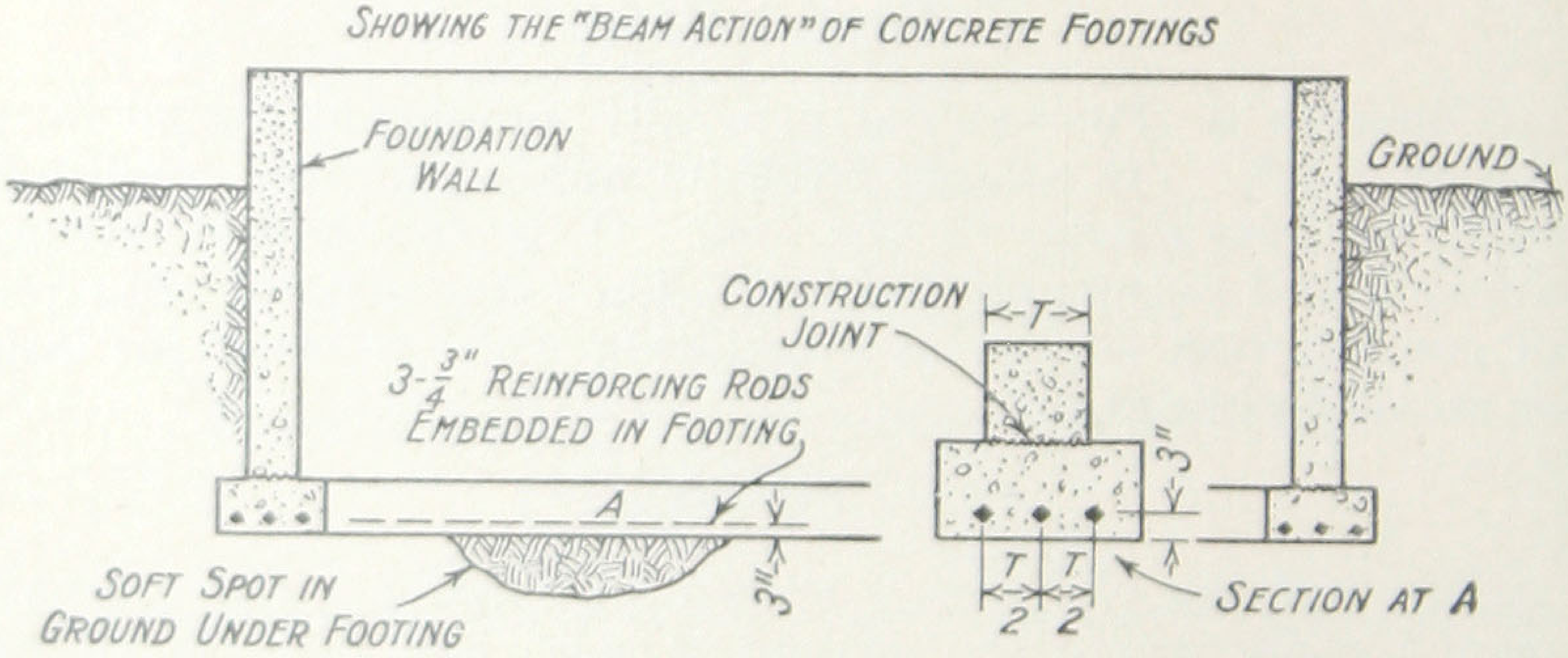



Fig. 69.—Example of the use of reinforcing in footings for bridging over soft spots.

## Reinforced Foundation

A wall so reinforced as shown in Fig. 69 acts as a beam in carrying the wall across soft spots or uneven bearing in the foundation material. It, of course, involves careful consideration of the loads so as to secure the right proportion of the wall and footings and the proper amount of reinforcement. Sometimes the concrete basement wall acts as a slab, supported at each end (by the side walls) and on one side (by the floor). When the pressure is considerable the wall should be reinforced accordingly. This condition occurs when there is pressure on the side due to soft soil, or, as is sometimes the case, due to ground water.

## Size and Mixture

For medium size buildings the basement walls are generally 10 to 12 inches thick. For larger work the thickness is made greater, up to 15 or 18 inches, or reinforcement is used, depend-upon conditions. The mixture is 1:2½:5 for ordinary conditions; in case of water pressure a mixture of 1:2:4 or 1:2:3 should be used. (See page 27.) In pouring concrete foundation walls the tendency is to make the concrete too wet. Much better strength and density are secured by using a mixture of only medium consistency described on pages 10-13.

## TABLE 18

## MATERIALS FOR SMALL FOUNDATION WALLS OF CONCRETE*

### Wall 7 Ft. High—Material Needed for Each 10 Ft. Length

| Thickness | 1:2:4 Mixture | | | 1:2½:5 Mixture | | | 1:3:6 Mixture | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bags Cement | Cubic Feet Sand | Cubic Feet Stone | Bags Cement | Cubic Feet Sand | Cubic Feet Stone | Bags Cement | Cubic Feet Sand | Cubic Feet Stone |
| 8 in. | 10⅓ | 20⅗ | 41⅕ | 8⅕ | 21 | 42 | 7½ | 22⅖ | 44⅘ |
| 9 in. | 11⅗ | 23⅘ | 46⅖ | 9⅖ | 23⅗ | 47⅖ | 8⅖ | 25⅕ | 50⅖ |
| 10 in. | 12⅘ | 25⅗ | 51⅖ | 10½ | 26⅖ | 52½ | 9⅖ | 28 | 56 |
| 12 in. | 15⅖ | 30⅘ | 61⅗ | 12⅗ | 31½ | 63 | 11⅕ | 33⅗ | 67⅕ |
| 18 in. | 23 | 46⅕ | 92⅖ | 18⅘ | 47⅕ | 94⅖ | 16⅘ | 50⅖ | 100 |

### Wall 8 Ft. High—Material Needed for Each 10 Ft. Length

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8 in. | 11⅘ | 23½ | 47 | 9⅗ | 24 | 48 | 8½ | 25½ | 51⅕ |
| 9 in. | 13⅕ | 26⅖ | 52⅘ | 10⅘ | 27 | 54 | 9⅗ | 28⅘ | 57⅗ |
| 10 in. | 14⅗ | 29⅖ | 58½ | 12 | 30 | 60 | 10⅗ | 32 | 64 |
| 12 in. | 17⅗ | 35⅕ | 70⅖ | 14⅖ | 36 | 72 | 12⅘ | 38⅖ | 76⅘ |
| 18 in. | 26⅖ | 52⅘ | 106 | 21⅗ | 54 | 108 | 19⅕ | 57½ | 115 |

### Wall 9 Ft. High—Material Needed for Each 10 Ft. Length

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8 in. | 13⅕ | 26½ | 53 | 10⅘ | 27 | 54 | 9⅖ | 28⅘ | 57½ |
| 9 in. | 14⅘ | 29⅗ | 59⅕ | 12⅕ | 30⅖ | 60⅘ | 10⅘ | 32⅖ | 64⅘ |
| 10 in. | 16½ | 33 | 66 | 13½ | 33⅘ | 67½ | 12 | 36 | 72 |
| 12 in. | 19⅘ | 39⅗ | 79⅕ | 16⅕ | 40½ | 81 | 14⅖ | 43⅕ | 86⅖ |
| 18 in. | 29¾ | 59½ | 119 | 24⅖ | 60⅘ | 121 | 21⅗ | 64⅘ | 130 |

### Material for Each 10 Ft. of Length of Footings 1:3:6 Mixture

| Size (height x width) | Cement Bags | Sand Cu. Ft. | Stone Cu. Ft. |
|---|---|---|---|
| 6 in. x 12 in. | ⅘ | 2⅖ | 4⅘ |
| 7 in. x 14 in. | 1⅛ | 3⅜ | 6¾ |
| 8 in. x 16 in. | 1½ | 4⅓ | 8⅔ |
| 9 in. x 18 in. | 1⅘ | 5⅓ | 10⅗ |
| 10 in. x 20 in. | 2⅕ | 6½ | 13 |
| 12 in. x 24 in. | 3⅙ | 9⅓ | 18⅗ |
| 15 in. x 30 in. | 5 | 14⅗ | 29⅖ |

*This table is for estimating the materials necessary for small foundation walls such as those for houses and small buildings. When stimating these, be sure to make deductions for any wall or door-openings. The 1:2:4 mixture is given for foundation walls where soil is wet and a water-tight concrete is necessary. Because the quantities involved in the table are small, the cement is given in bags and the sand and stone in cubic feet. To change the cement quantities to barrels divide by 4 and to change the sand and stone quantities to cubic yards divide by 27. For foundation walls provided with footings, add the quantities taken from the footing table.

## FOOTINGS

The simplest form of footing construction is plain concrete. It approximates the shape of the old spread masonry footing and is generally used for light structures. The thickness of the plain concrete footing must be sufficient to prevent the column punching through it and the spread of the base should be large enough so that the bearing capacity of the soil is not exceeded.

Reinforcing is used in a footing in order to decrease the quantity of concrete required as well as to save on the quantity of excavation. The reinforcing placed in the bottom of the slab prevents its buckling and breaking from the concentrated load of the column. Mixture for footings is generally 1:2½:5.

**TABLE 19**

**Bearing Power of Soils in Tons per Square Foot**

| | Minimum | Maximum |
|---|---|---|
| Rock, hardest | 200 | .... |
| Rock equal to best ashlar masonry | 25 | 30 |
| Rock equal to best brick masonry | 15 | 20 |
| Rock equal to poor brick masonry | 5 | 10 |
| Clay, thick beds, always dry | 6 | 8 |
| Clay, thick beds, moderately dry | 4 | 6 |
| Clay, soft | 1 | 2 |
| Gravel and coarse sand, hard | 8 | 10 |
| Sand, dry, well packed | 4 | 6 |
| Sand, clean, dry | 2 | 4 |

## FLOORS

### Plain Floors

Plain concrete floors are of two types—one course and two course. The one course has the advantage over the two course in the saving of labor and materials. Less labor is required for mixing and laying, since there is only one mixture and only one striking off. The one course consists of a uniform mixture throughout—1:2:3. The two course consists of a base of 1:2½:5 and a top course of 1:2 mortar or 1 part cement, 1 part sand and 1 part grits up to ¼-inch in size.

In constructing basement floors where good drainage exists, the floor is generally laid right on the ground. If the floor is to be subjected to water pressure the membrane system of waterproofing is used and no joints made. Under heavy pressure the floor is reinforced to resist the upward thrust of the water. In this case the reinforcement would be laid near the top of the slab. The floor may be laid in alternate sections or placed continuously, using strips of tar paper so as to separate it into sections. Sections usually do not exceed 10 feet square. The customary thickness of basement floors is 4 or 5 inches.

## Reinforced Floors

The thickness of the floor depends upon the load to be carried. For short spans see Table 6 In reinforced concrete building construction a smooth finish floor is generally desired. The mortar finish should be 1-inch thick. This is an additional thickness to that of the floor slab required for carrying

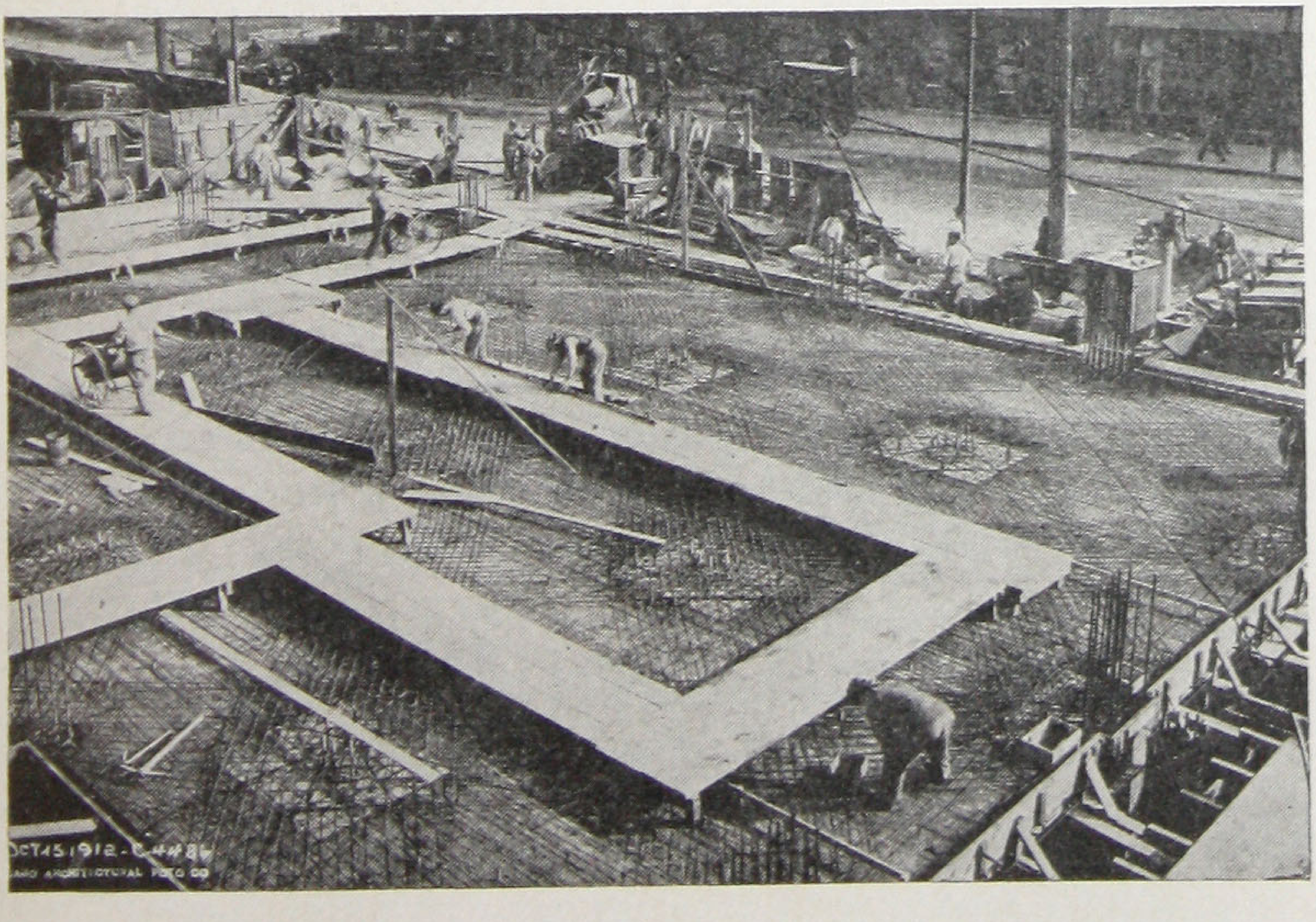


Fig. 70.—An example of flat slab floor construction. Notice reinforcing in place and runways for wheeling concrete buggies to allow for convenient depositing of concrete.

## TABLE 20

## *QUANTITIES FOR ONE-COURSE SIDEWALKS AND FLOORS

### 100 Square Feet of Surface

| Thickness Inches | Cubic Yards of Concrete per 100 Sq. Ft. | 1:2:3 Mix | | | 1:2:4 Mix | | |
|---|---|---|---|---|---|---|---|
| | | Cement Bbls. | Sand Cu. Yds. | Stone Cu. Yds. | Cement Bbls. | Sand Cu. Yds. | Stone Cu. Yds. |
| 3 | 0.93 | 1.62 | 0.48 | 0.72 | 1.41 | 0.42 | 0.83 |
| 3½ | 1.08 | 1.88 | 0.56 | 0.83 | 1.63 | 0.49 | 0.96 |
| 4 | 1.22 | 2.14 | 0.63 | 0.94 | 1.84 | 0.55 | 1.09 |
| 4½ | 1.39 | 2.42 | 0.72 | 1.07 | 2.10 | 0.62 | 1.23 |
| 5 | 1.54 | 2.68 | 0.80 | 1.18 | 2.33 | 0.69 | 1.37 |
| 5½ | 1.70 | 2.96 | 0.88 | 1.31 | 2.56 | 0.76 | 1.51 |
| 6 | 1.85 | 3.22 | 0.96 | 1.42 | 2.79 | 0.83 | 1.64 |

## *QUANTITIES FOR TWO-COURSE SIDEWALKS AND FLOORS

### 100 Square Feet of Surface

| Thickness Inches | BASE COURSE | | | | | |
|---|---|---|---|---|---|---|
| | 1:2½:5 Mix | | | 1:3:6 Mix | | |
| | Cement Bbls. | Sand Cu. Yds. | Stone Cu. Yds. | Cement Bbls. | Sand Cu. Yds. | Stone Cu. Yds. |
| 3 | 1.15 | 0.43 | 0.85 | 0.98 | 0.43 | 0.87 |
| 3½ | 1.34 | 0.50 | 0.99 | 1.15 | 0.51 | 1.02 |
| 4 | 1.51 | 0.56 | 1.12 | 1.29 | 0.56 | 1.12 |
| 4½ | 1.72 | 0.64 | 1.28 | 1.47 | 0.65 | 1.31 |
| 5 | 1.91 | 0.71 | 1.42 | 1.63 | 0.72 | 1.44 |

| Thickness Inches | TOP COURSE | | | | | |
|---|---|---|---|---|---|---|
| | 1:1 Mix | | 1:1½ Mix | | 1:2 Mix | |
| | Cement Bbls. | Sand Cu. Yds. | Cement Bbls. | Sand Cu. Yds. | Cement Bbls. | Sand Cu. Yds. |
| ½ | 0.75 | 0.11 | 0.60 | 0.13 | 0.50 | 0.15 |
| ¾ | 1.13 | 0.17 | 0.90 | 0.20 | 0.75 | 0.22 |
| 1 | 1.50 | 0.22 | 1.20 | 0.27 | 1.00 | 0.29 |

* The quantities given in this table are based on exact thicknesses and with no allowance for waste. Variations and inaccuracies in the sub-grade may cause quantities to differ from the figures given in the table.

the load. The finish is screeded with a straight-edge, smoothed with a wooden float and later finished with a steel trowel. If the base has hardened before placing the finish it is very important that it be properly prepared, so that the mortar finish will adhere firmly. It is necessary to roughen and clean the concrete base thoroughly. All loose material should be cleaned from the surface. The concrete should be thoroughly drenched so that it will not absorb any moisture from the finish mortar. The base is then given a coat of grout which is simply cement and water applied with a whitewash brush, and is then ready for an *immediate* application of the mortar finish. The mixture for the slab is 1:2:4, and for the finish 1:2, or 1:1:1 as noted.

## Terrazzo Floor Finish

Terrazzo floors are used for corridors, halls and display rooms. They are built by using crushed marble of various colors, graded from $\frac{1}{16}$ to $\frac{1}{2}$-inch, with portland cement, and polishing when the mixture has hardened sufficiently. A good method is to use 1 part Atlas-White Cement and 2 parts crushed marble, and apply this mortar to the concrete slab to a thickness of $\frac{3}{4}$ to 1 inch, as in the case of monolithic work. After this mixture has been spread and screeded it is rolled with a roller and additional marble chips added until the mixture will accept no more. The surface is then thoroughly troweled and allowed to become sufficiently hard to be rubbed with carborundum block or a power surfacing machine. Such a method of construction produces a very attractive, hard, durable floor.

The use of Atlas White Portland Cement results in a more handsome appearance than when regular gray cement is employed, because the white matrix of cement by contrast shows up the marble chips to best advantage. The use of sheet-brass dividing strips in terrazzo floor is becoming general as a means for avoiding contraction cracks.

## COLUMNS

The columns of a building are the most important individual members and careful consideration in construction is essential.

Concrete columns should always be placed first, allowing opportunity for settlement before placing floor slabs. There is more money to be lost or saved in carpenter and labor work on column form construction, erection and stripping than on any other part of the work.

While there are many variations in column shapes, the square column is preferred because the forms are easily and economically built, and can be erected and stripped quickly. The development of steel forms for round columns has decreased the cost of round column construction, however, and there is an increasing use of round columns, especially with flat slab floors where the flarehead column is necessary. If the contractor does not have his own forms, he can rent them. See page 46 on columns, and page 60 on forms. The mixture used in columns should be not leaner than 1:2:4.

## ROOFS

Reinforced concrete roofs are essentially floors (see floors page 90) and are constructed as such. The pitch may be made in the roof itself or drainage may be provided by a cinder fill or cinder concrete upon which is placed tar and gravel, or other form of roof covering. It is considered advisable always to use some form of roofing material on top of the plain concrete slab.

## WALLS, PARTITIONS, ETC.

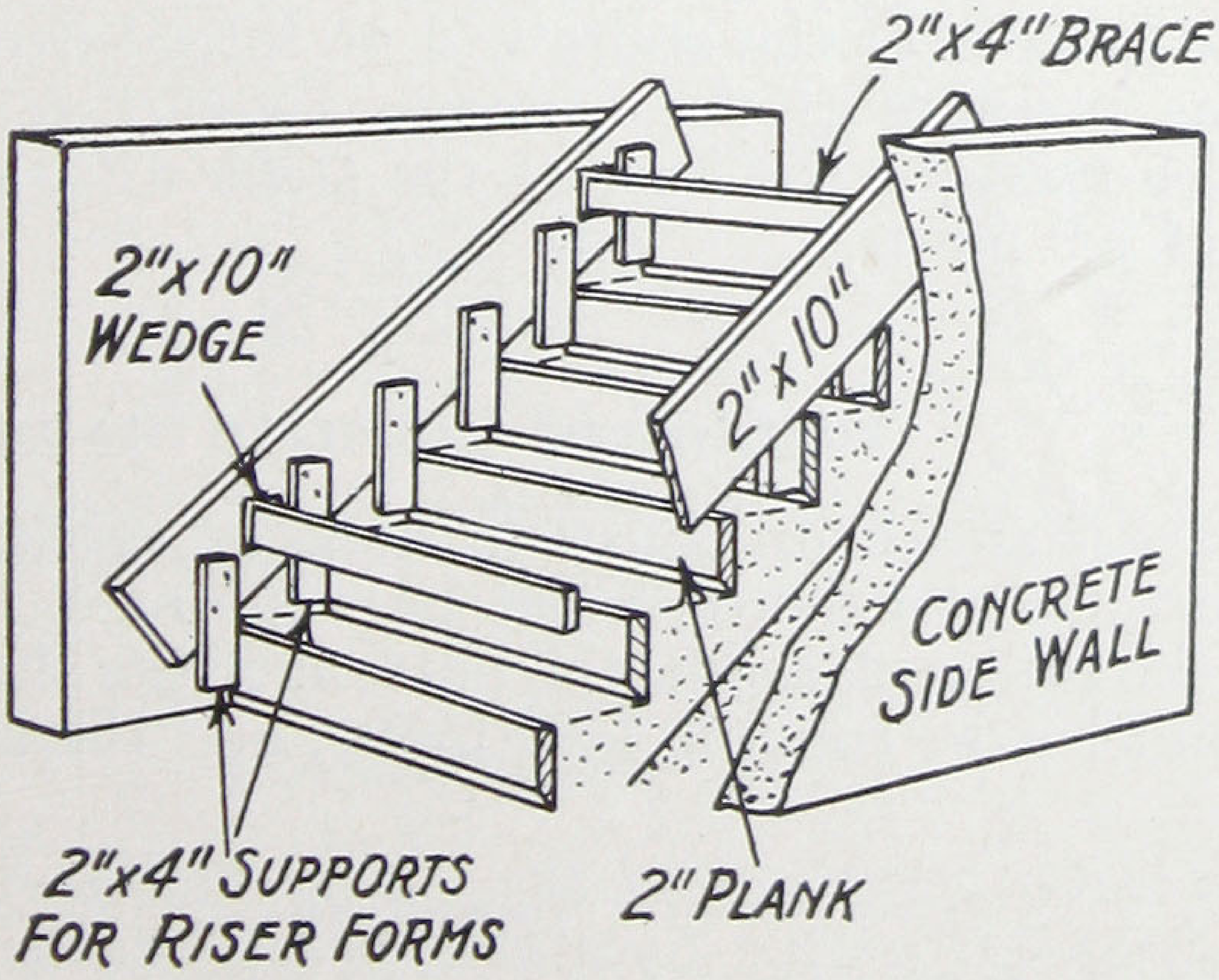
Walls of the skeleton type in reinforced concrete buildings are called curtain walls and are generally constructed after the skeleton is put up. Slots in the columns are left in order to provide a mortise for the panels. See Fig. 61, page 76 for forms. Ordinary concrete walls require light reinforcing to prevent shrinkage and give them stiffness while setting. Curtain walls of concrete buildings are not designed to carry weight.

# STEPS AND STAIRS

## Forms

Fig. 71 shows forms for concrete steps that are built on the ground and not reinforced. The forms for this type of step construction consist of two planks braced against the side walls by 4 x 4's and wedges. To these are nailed 2 x 4's which come to within a couple of inches of the treads. To the 2 x 4's are nailed the cross planks which form the risers. In actual construction it is better to fasten the 2 x 4's to the planks in proper position before the planks are braced against the wall.

Fig. 71.
Forms for steps supported on ground. If there is any doubt about supporting power of the earth a few reinforcing bars should be placed in the steps to prevent cracking.



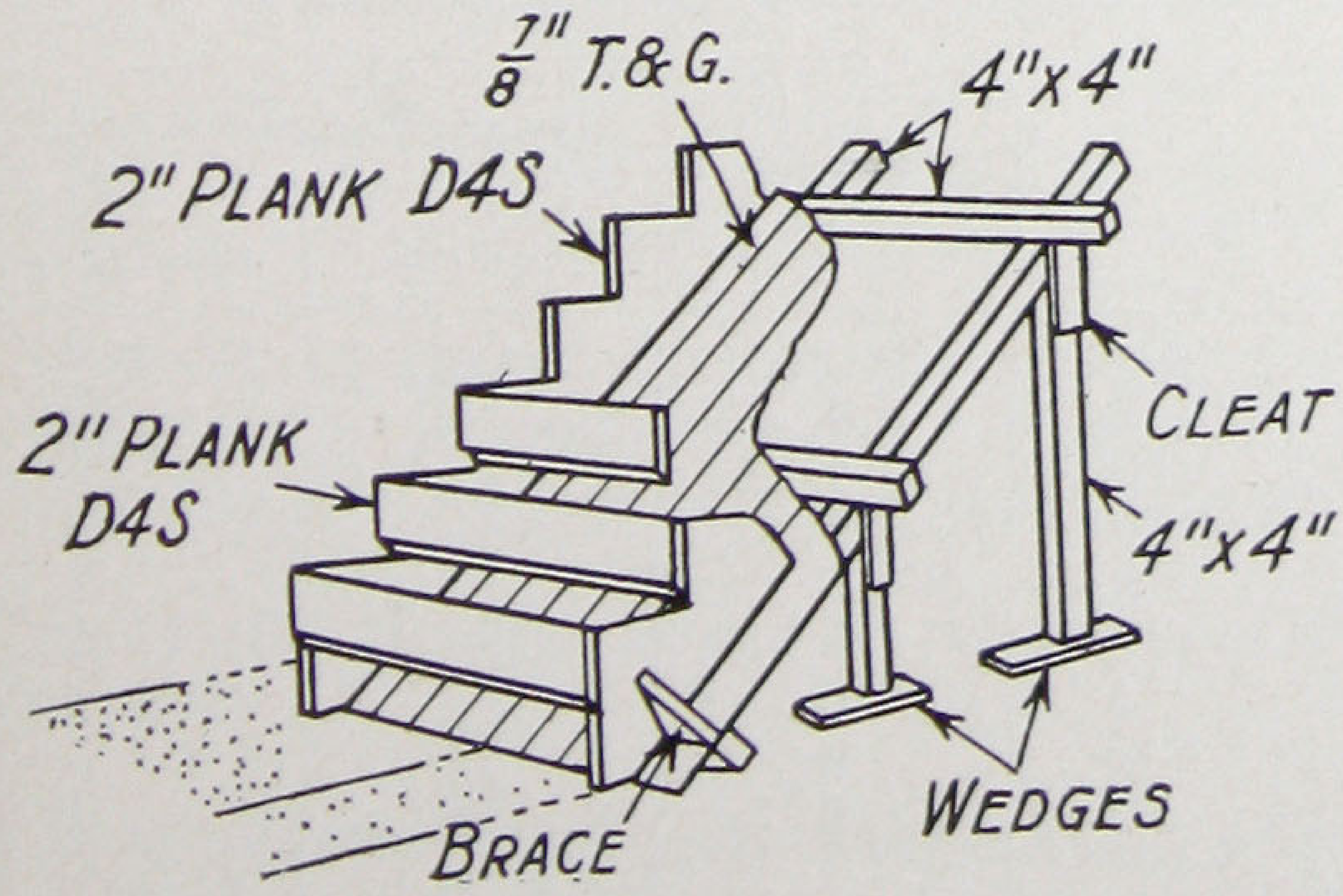




Fig. 72.
Forms for self-supporting reinforced steps. This type of step has a clear space beneath, and must be supported either at the sides or at top and bottom.

The forms for the risers can be stripped 24 hours after the concrete is poured and the face of the riser finished to a smooth surface by rubbing with a wood float dipped in water and sand.

Where concrete steps are built without the side walls a different form is used. It is made of planks cut according to the risers and treads of the steps, and the forms for the risers are nailed to the plank. This form is practically the same as for reinforced concrete steps.

## Construction

As soon as the concrete base is poured the treads should be finished. The mixture should not be too wet or the concrete at the bottom of the stairs will be forced over the riser forms by the pressure of the concrete above. A 1:2½:5 mixture may be used for the base of the steps with a ¾-inch surface coat of 1:2 mortar.

## Reinforced Concrete Stairs

Stairs that are not constructed on an earth fill must be self-supporting, and hence, must be reinforced. The reinforcing steel should be placed in the bottom of the slab, one inch from the under side, running lengthwise, and the amount will vary

### TABLE 21

**Table of Reinforcement for Concrete Stairs**

| Number of Steps | Clear Span | | Thickness Slab | Longitudinal Reinforcement | |
|---|---|---|---|---|---|
| | | | | Diameter | Spacing Rods |
| | Feet | Inches | Inches | Inches | Inches |
| 4 | 2 | 2 | 4 | ½ | 10 |
| 5 | 3 | 0 | 4 | ½ | 10 |
| 6 | 3 | 10 | 4 | ½ | 7 |
| 7 | 4 | 8 | 5 | ½ | 7 |
| 8 | 5 | 6 | 5 | ½ | 5 |
| 9 | 6 | 4 | 6 | ½ | 5 |
| 10 | 7 | 2 | 6 | ⅝ | 5 |
| 11 | 8 | 0 | 6 | ⅝ | 4 |

according to the length of the slab. The reinforcing for different length stairs is shown below.

## Forms

The forms required for self-supporting stairs are shown in Fig. 72. They consist of a panel of ⅞-inch tongue and groove sheathing cleated together, and about 12 to 14 inches wider on each side than the stairs. This panel is supported on 4 x 4's longitudinally, which in turn are supported on 4 x 4″ bents as shown. The planks forming the side forms are nailed to the panels and braced on the outside.

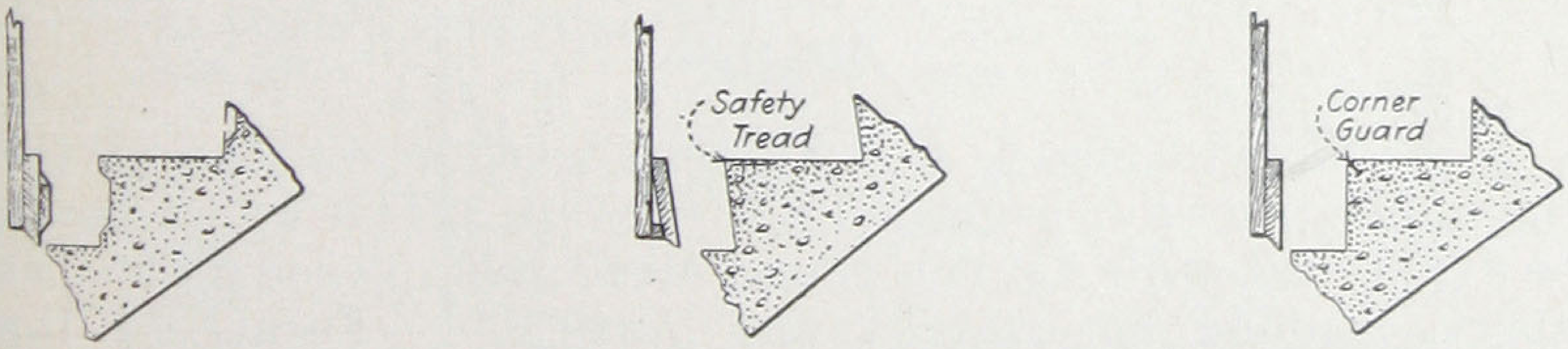



Fig. 73.—Three types of riser form for concrete steps. It is best to have the tread under-cut in same manner as shown in the center rather than the type shown at the right.

## Construction

The entire slab should be poured at one time. The longitudinal reinforcement should be placed before the forms for the risers are attached and the rods in the edge of the steps placed when the concrete is poured. The mixture used should be 1:2:4. The placing of the body of the concrete should be followed at once by the ¾-inch surfacing.

The side and riser forms can be removed 24 hours after the concrete is poured, but the forms and shoring supporting the stair slab should be left in place at least four weeks.

Fig. 73 shows three types of riser forms which have proven satisfactory.

Where unusual traffic conditions exist, as in railroad stations and factories, metal treads are used.

## A TYPICAL SMALL REINFORCED CONCRETE BUILDING

### For Example—A One-Story Private Garage

A construction for garages is described in this section because it is a typical small concrete building. With some slight modification these directions may be used for tool house repair shop, small storehouse or for any one of many purposes.

### Foundation

For a one-story garage, foundations need not be more than 10 inches thick with a spread foundation if soil conditions warrant; page 87. The common mixture is 1:2½:5.

### Walls

A reinforced concrete wall 8 inches thick is satisfactory for the superstructure, using a 1:2:4 mixture. The walls should be reinforced with ⅜-inch round steel rods, placed 14 inches apart, running horizontally and vertically. Forms for the walls are shown on pages 58 and 59.

### Openings

Frames for forming the window and door openings should be placed in the forms at the time the concrete is being poured. Fig. 52.

### Roof

The roof may be made either peaked or flat. The one shown in the drawing has a slope of about 4 inches toward the back of the building. It is made 7 inches thick of a 1:2:4 mixture, and reinforced with ⅜-inch round steel rods spaced 5 inches apart crosswise, and 9 inches apart lengthwise of the building, and located 1 inch from the bottom of the slab. The rods are wired together where they cross each other so as to prevent any shifting while placing the concrete. A concrete beam 5 inches wide x 14 inches deep, including the thickness of the roof, is placed over the doorway. This beam is reinforced with ½-inch square twisted steel rods, placed 2 inches from the bottom. Forms for the roof consist of a flat platform of

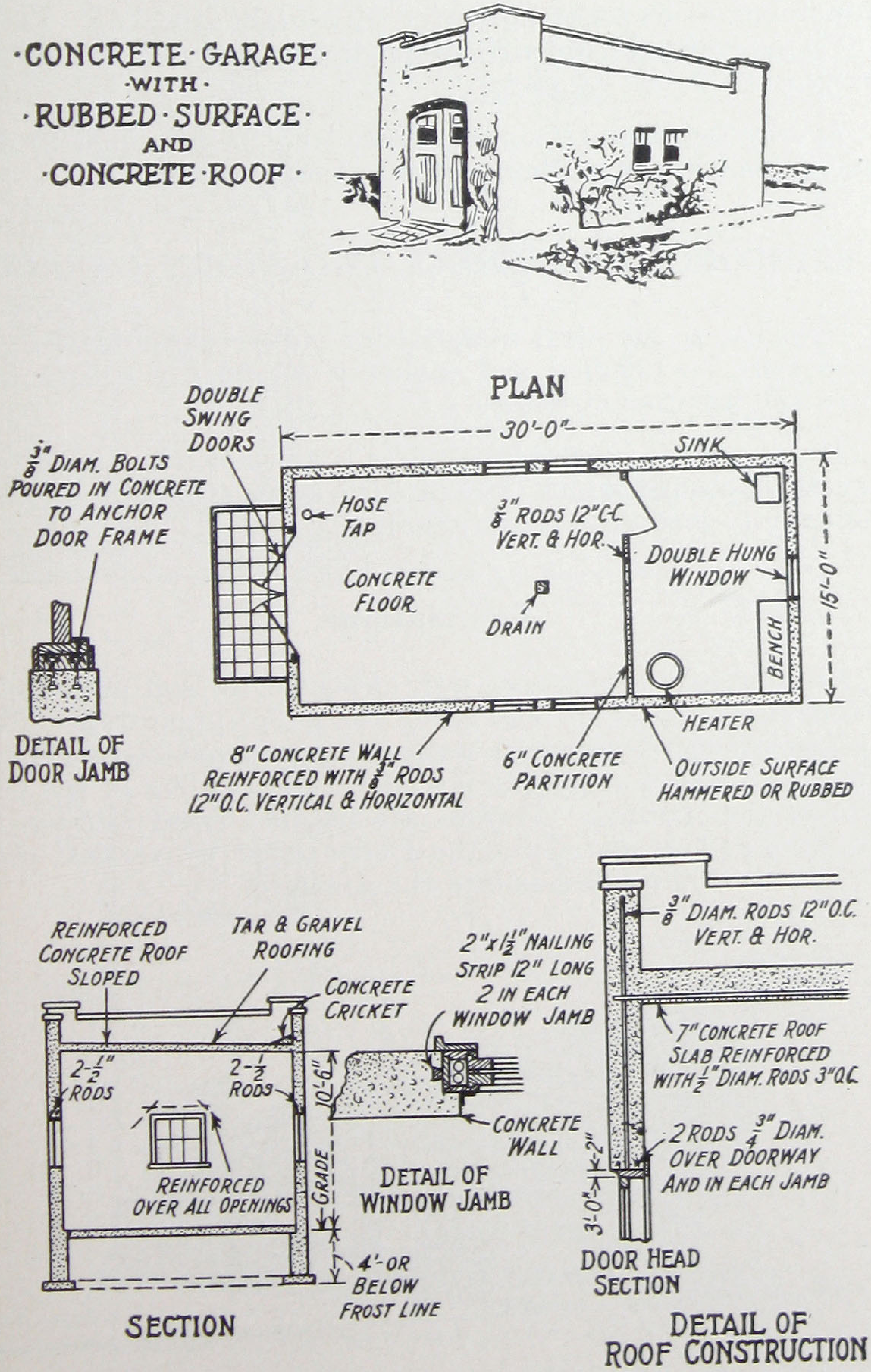



Fig. 74.—Details of small private garage construction.

1-inch boards on joists supported by upright studding. Forms are strongly made and well supported so as to safely hold the weight of the wet concrete.

A very satisfactory surface finish may be obtained by employing one of the methods described on pages 36-39.

## REINFORCED CONCRETE TWO-STORY GARAGE

Concrete is the ideal material for garage construction. It can easily be handled and makes a thoroughly substantial, rigid and fireproof structure.

The layout and construction details are shown herewith for a two-story garage, which illustrate the application of reinforced concrete to two-story construction.

### Foundations

Foundations in this case were designed for soil pressure of 3 tons per square foot, and are of the plain spread type. The footings of the foundation walls are reinforced in two directions with round steel rods placed within 4 inches of the bottom of the footings. Dowels are used to bond footings to columns and to distribute the load carried by vertical reinforcement of the columns into the concrete.

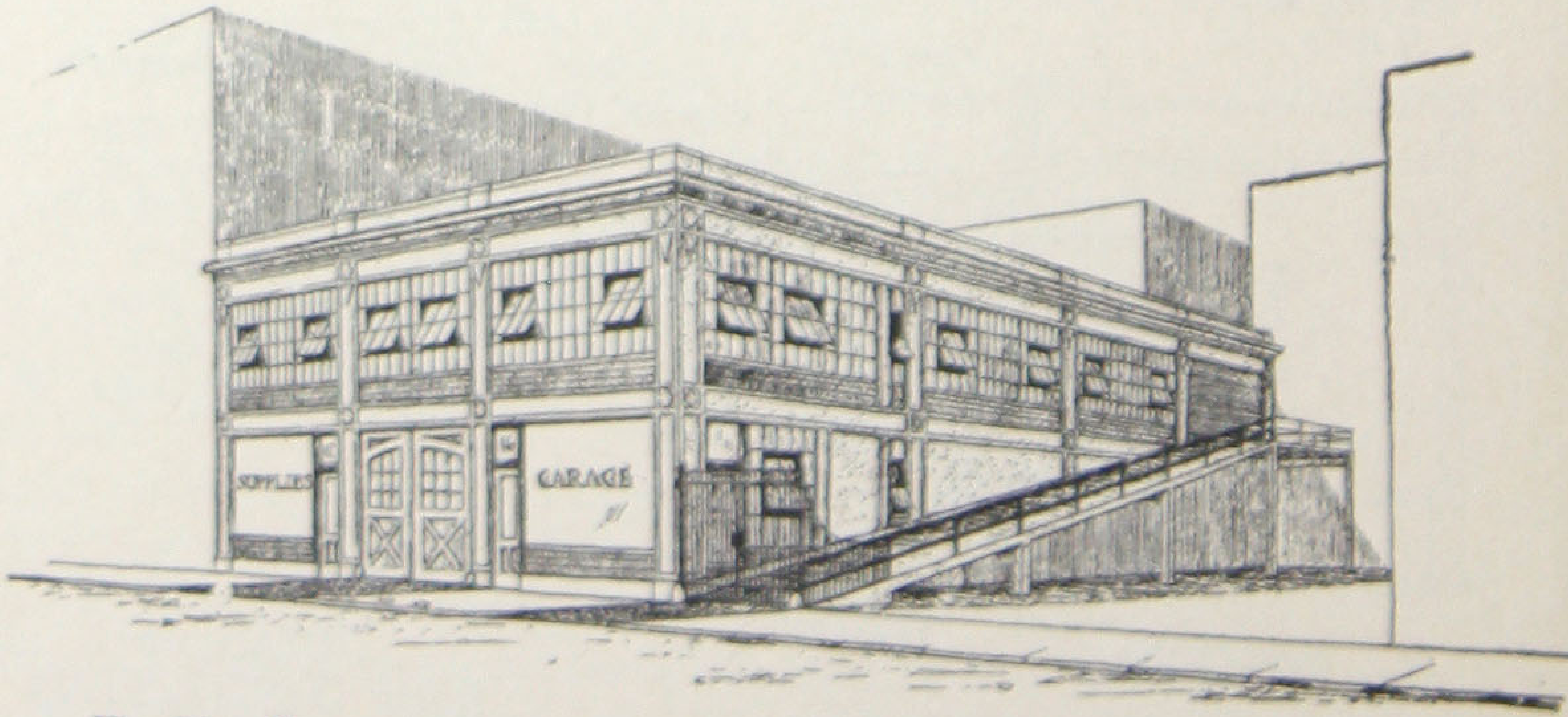



Fig. 75.—Two-story commercial garage with inclined runway to second floor.

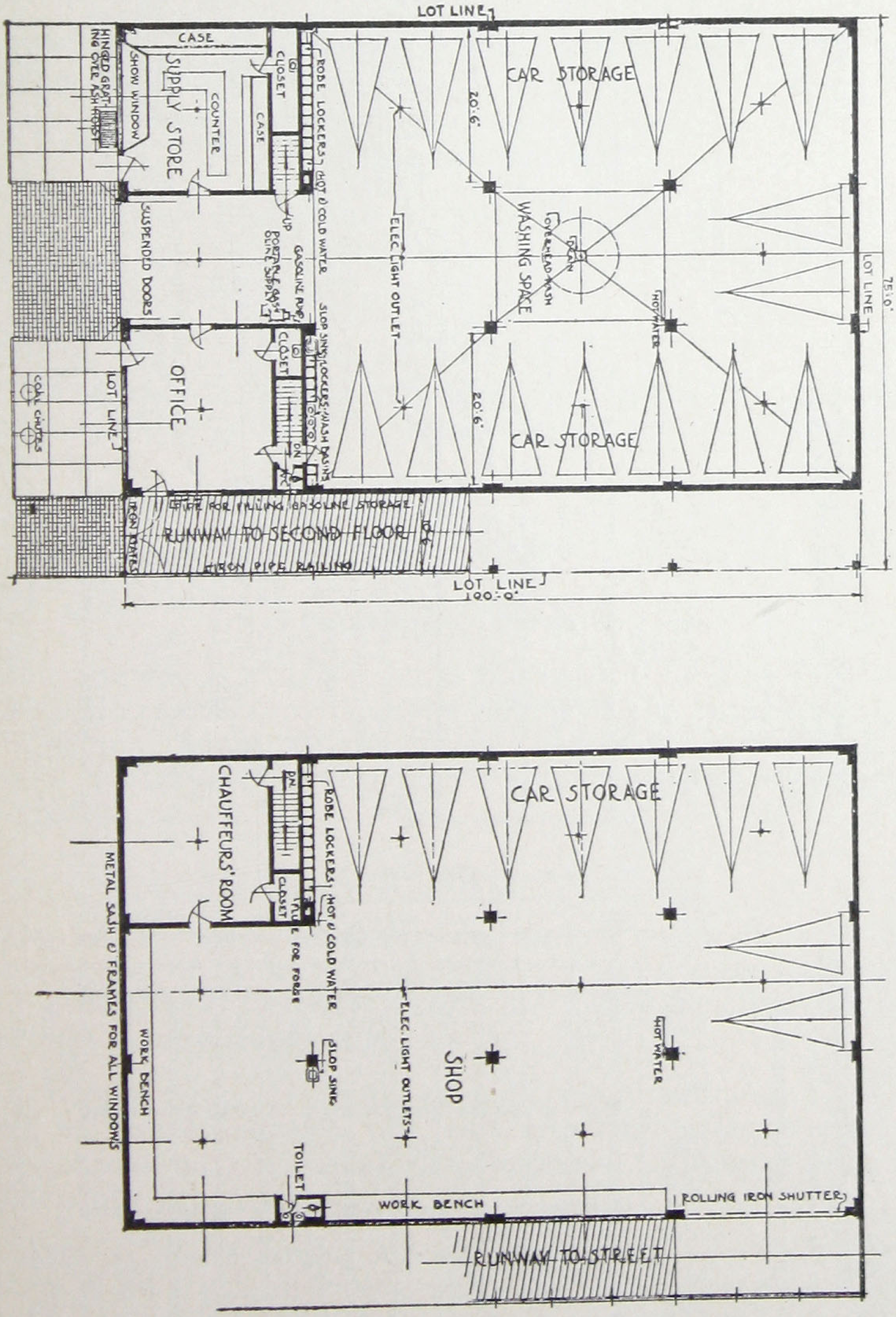



Fig. 76.—Floor plan of garage shown in Figure 75.

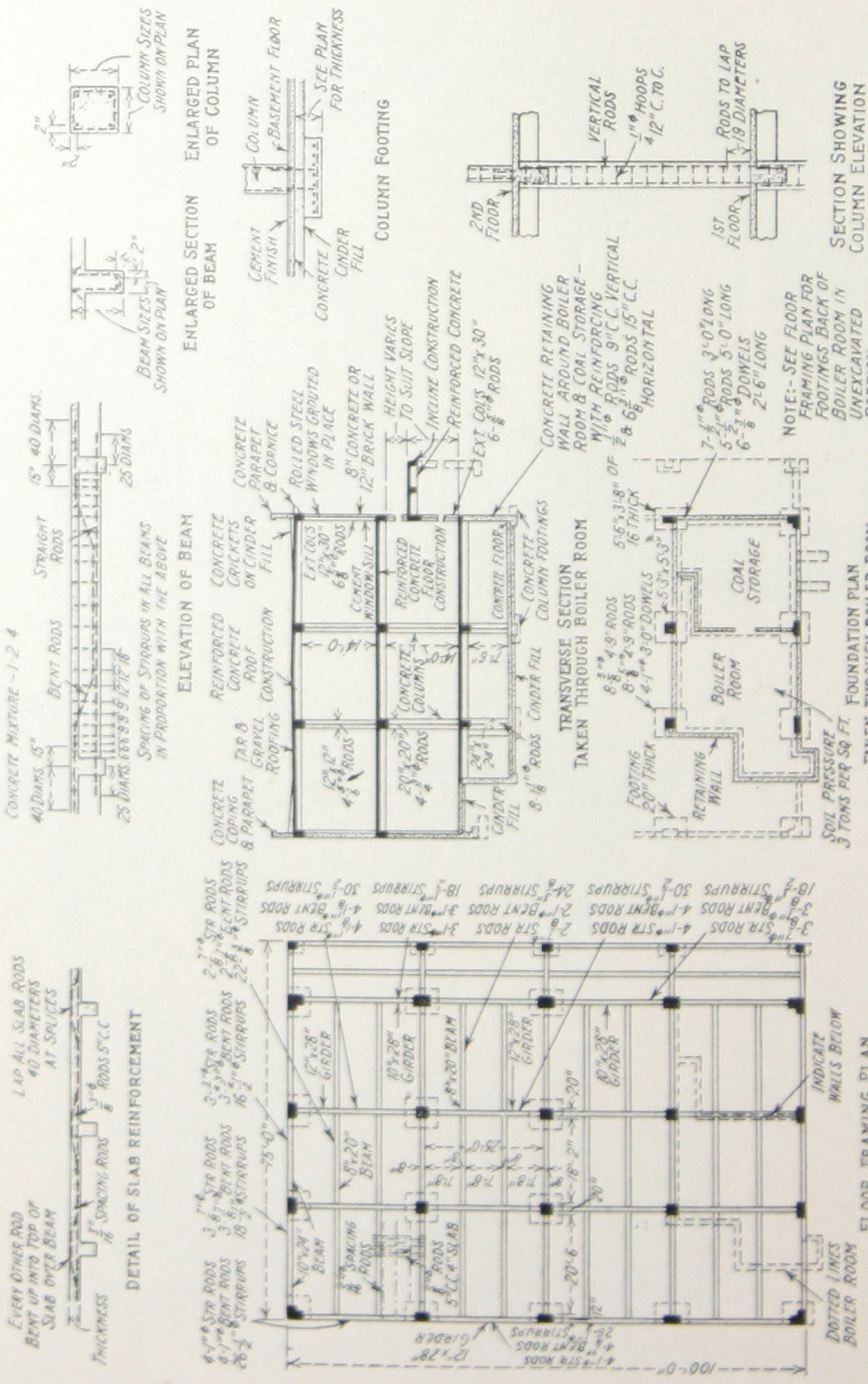



**Fig. 77.—Details of two-story concrete garage.**

### Columns

The columns are reinforced with vertical steel only, tied together with light hoops, Fig. 43.

### Floor Construction

This is beam and girder design. The details are shown in Fig. 77. This type of construction is what is known as monolithic skeleton type.

### Roof

The roof is constructed as a floor. A slope is provided by a cinder fill upon which the usual tar and gravel covering is applied.

### Walls

The walls are 8 inches thick. Round steel rods are used for reinforcement.

### Inclined Runway

The runway is constructed at the same time as the framework of the building. The pipe railing on the outside is built of 2½-inch piping with standard fittings. The building is shown in Fig. 75. Further details on garage construction will be gladly sent.

## TANKS

One of the most advantageous uses of concrete is in the construction of tanks. It combines strength, water-tightness and durability. Concrete tanks are easily constructed and are built in any size or shape.

Concrete tanks are built to hold many different liquids, such as: water, mineral oils, salt brine, molasses, vegetable and animal oils, miscellaneous chemical solutions, tanning liquids and dairy products.

Many of these liquids are stored in plain concrete tanks; others require special treatment on the interior surface. For specific information on solving your storage problem write The Atlas Portland Cement Company.

(**Tanks**—*Continued on next page*)

## Construction

The general principle of construction, such as foundations, mixture, placing, etc., are the same for all tanks. The kind and shape of forms vary and also the thickness of walls and the amount of reinforcement.

The location must first be determined in order to decide upon the proper shape and design of the tank. In selecting the size it should be remembered that 7½ gallons equal one cubic foot. The size of tank runs from small watering troughs with a few barrels capacity to large tanks or reservoirs holding many thousand gallons.

## Foundations

The best foundation is a thoroughly and uniformly compacted soil evenly supporting the entire tank floor. In soft soil it may be necessary to dig trenches and build foundation walls. In such cases additional reinforcing should be used in the floor.

## Forms

Forms for rectangular or square tanks are made in a manner similar to wall forms shown on page 58. In circular tank construction of large size either movable forms are used as

TABLE 22

Reinforcement for Bottom of Rectangular Tanks

| Depth of Tank | Thickness of Floor | Spacing of ⅜" Round Rods | Spacing of ½" Round Rods | Spacing of ¾" Round Rods |
|---|---|---|---|---|
| Feet | Inches | Inches | Inches | Inches |
| 3 | 6 | 10 | .... | .... |
| 4 | 6 | 8 | 16 | .... |
| 5 | 7 | 7½ | 15 | .... |
| 6 | 7 | 7 | 14 | .... |
| 7 | 8 | 6½ | 13 | .... |
| 8 | 8 | 6 | 12 | 24 |
| 9 | 10 | 5 | 10 | 20 |
| 10 | 10 | 4 | 8 | 16 |

## TABLE 23

### Size and Spacing of Rods in Walls of Rectangular Tanks

| Depth of Tank | Thickness of Wall | Spacing of 3/8″ Round Rods | | Spacing of 1/2″ Round Rods | | Spacing of 3/4″ Round Rods | | Spacing of 1″ Round Rods | |
|---|---|---|---|---|---|---|---|---|---|
| | | Vertical | Horizontal | Vertical | Horizontal | Vertical | Horizontal | Vertical | Horizontal |
| Feet | Inches | Inches | Inches | Inches | Inches | Inches | Inches | Inches | Inches |
| 3 | 5 | 5 | 10 | 10 | 20 | .... | .... | .... | .... |
| 4 | 5 | 4 | 8 | 8 | 16 | 16 | 32 | .... | .... |
| 5 | 5½ | 3 | 6 | 6 | 12 | 12 | 24 | .... | .... |
| 6 | 6½ | 2½ | 5 | 5 | 10 | 10 | 20 | 18 | 36 |
| 7 | 8 | .... | .... | 3 | 6 | 7 | 14 | 16 | 30 |
| 8 | 9½ | .... | .... | 2½ | 5 | 5 | 10 | 11 | 22 |
| 9 | 10½ | .... | .... | .... | .... | 5 | 10 | 10 | 20 |
| 10 | 12 | .... | .... | .... | .... | 4 | 8 | 8 | 16 |

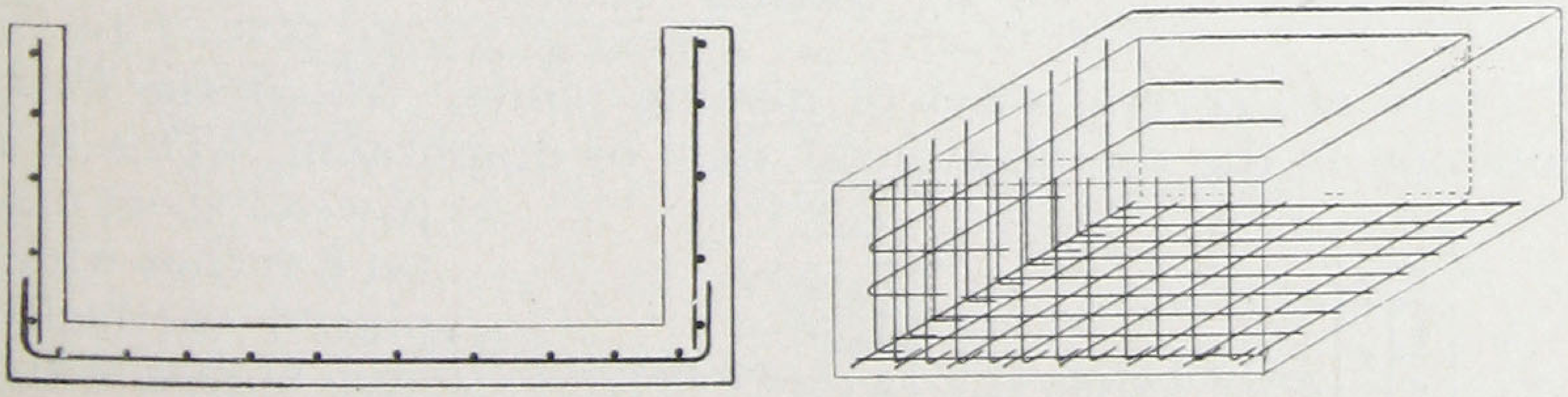


Fig. 78.—Example of placing steel reinforcing in rectangular tank. Notice how bars are bent up from floor into walls, and also around corners.

## TABLE 24

### Size and Spacing of Rods in Walls of Circular Tanks

| (1) Depth | (2) Diameter | (3) Thickness of Concrete in Wall | (4) Diameter of Horizontal Rods | (5) Spacing Horizontal Rods at Bottom | (6) Spacing Horizontal Rods at Top | (7) Diameter Vertical Rods | (8) Spacing Vertical Rods |
|---|---|---|---|---|---|---|---|
| Feet | Feet | Inches | Inches | Inches | Inches | Inches | Inches |
| 5 | 5 | 6 | ¼ | 8 | 18 | ¼ | 36 |
| 5 | 10 | 6 | ¼ | 6 | 12 | ¼ | 30 |
| 10 | 10 | 8 | ⅜ | 6 | 18 | ⅜ | 36 |
| 10 | 15 | 9 | ⅜ | 4 | 18 | ⅜ | 36 |
| 15 | 10 | 10 | ⅜ | 4 | 18 | ⅜ | 30 |
| 15 | 15 | 12 | ½ | 6 | 20 | ⅜ | 30 |

shown in Fig. 66 or forms for the entire height. If a contractor has several tanks to build, steel forms are generally more economical than wood.

## Proportions

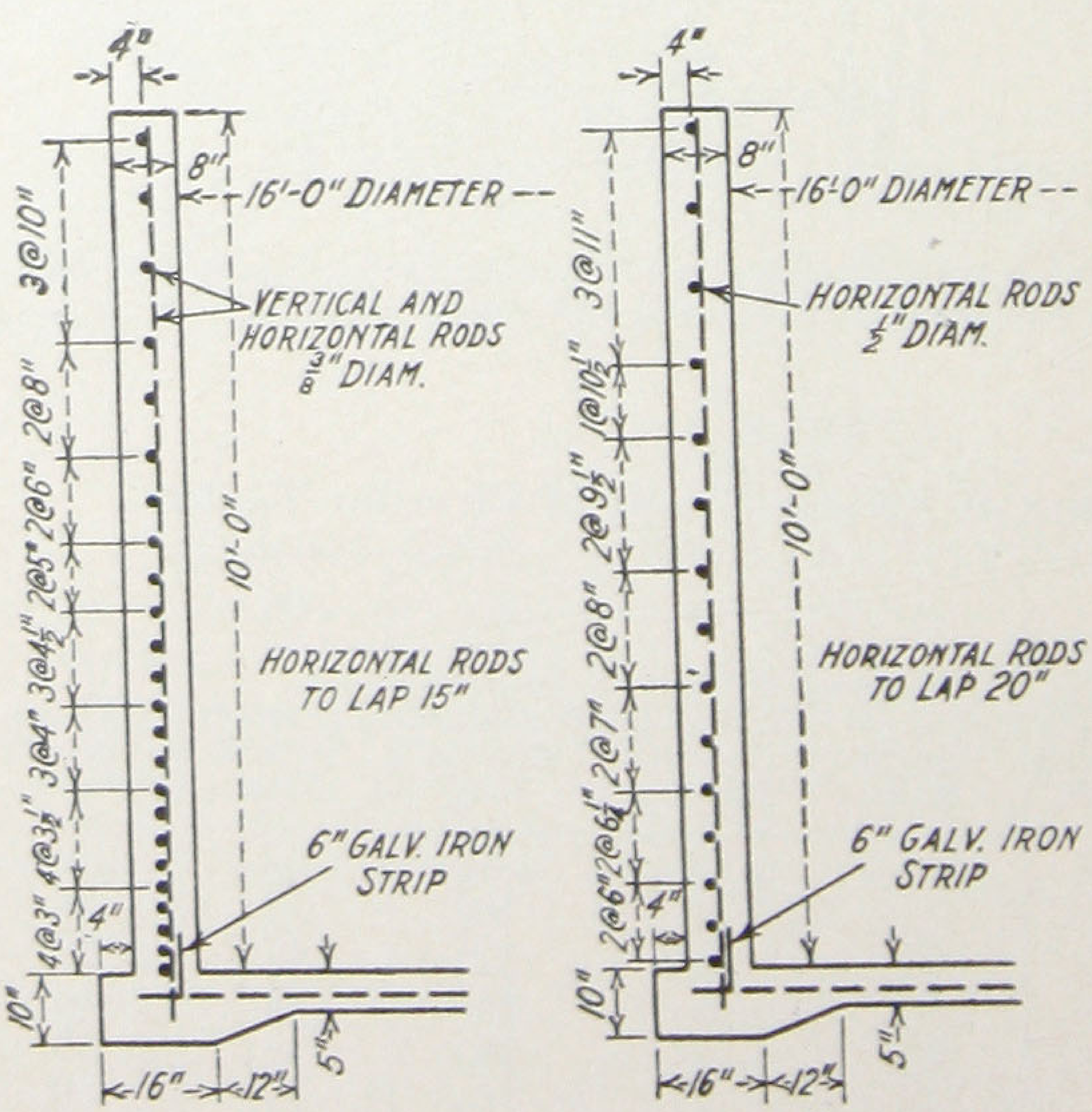
The proportions must be such as to secure a thoroughly dense concrete that will be water-tight. Usually for ordinary work a 1:2:3 mixture is used. For special work richer mixtures are necessary. See page 27 on watertight concrete.

## Placing

Concrete should be placed continuously if possible; otherwise, care should be taken to secure proper bond with the previously poured concrete. See page 35.

## Joints

There are several ways of making joints. About the most common is the use of a metal dam or diaphragm. This is a piece of sheet metal 6 inches wide, placed vertically and buried 3 inches deep in the old concrete, extending 3 inches into the new concrete.




SPACING OF 3/8" DIAM. RODS    SPACING OF 1/2" DIAM. RODS

Fig. 79.—Spacing of horizontal bars in 16' circular tank.

## Reinforcement

Reinforcement for rectangular and circular tanks is shown in the tables on page 105. It is put in the center of the wall as shown in Fig. 78-79, and the bars are lapped

at the junction of the bottom and sides, and around the corners. If necessary to splice the bar, they should be lapped 40 diameters.

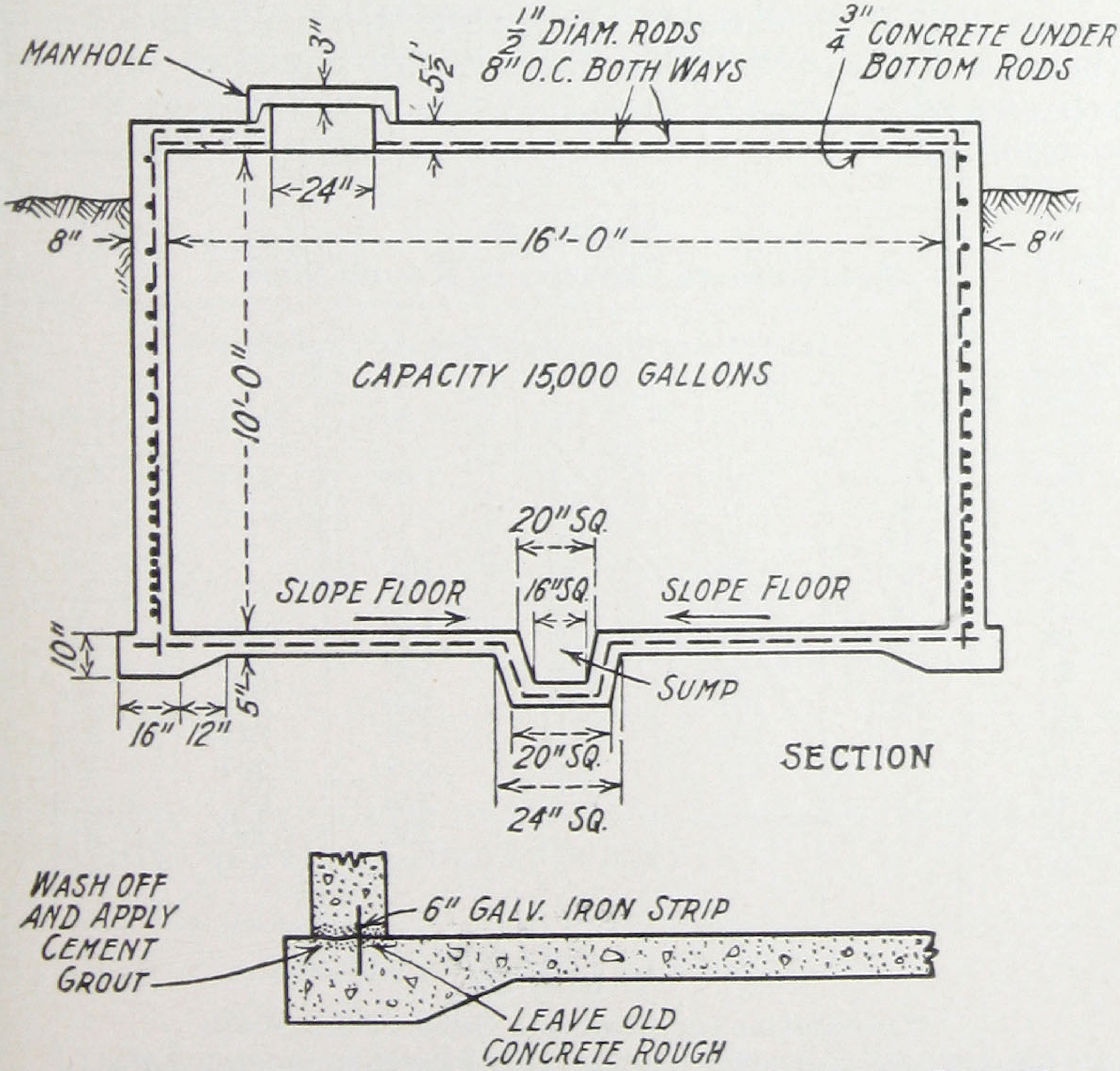



Fig. 80.—**Details of circular tank. Capacity** 15.000 gallons. **See Figure 79.**

**Quantities of Materials Required for Tank—(shown above)**

| | Concrete, 22½ Cu. Yd. Mix 1:2:3 | | | |
|---|---|---|---|---|
| | Cement Sacks | Sand Cu. Yd. | Stone Cu. Yd. | Reinforcement |
| 5½″ Roof Slab...... | 28 | 2 | 3¼ | ½″ rods—478 lb. |
| Floor.............. | 39 | 3 | 4¼ | ¼″ rods—67.7 lb. or wire mesh 42″ wide —84.5 lb. |
| Walls.............. | 91 | 6¾ | 10¼ | ⅜″ rods—663 lb. or ½″ rods—705 lb. |
| For 7″ Roof Slab use these quantities.... | 36 | 2¾ | 4½ | ⅝″ rods—625 lb. |

# CONCRETE SILOS

A concrete silo means a big saving for the farmer. It saves at least 40% of the corn crop by saving the stalks which would otherwise be wasted. Few farmers are equipped to build their own silos; most of them prefer to have this kind of construction handled by contractors. For forms see page 81.

### TABLE 25
**Approximate Capacity of Round Silos**

| Height of silo | Inside Diameter of Silo in Feet and Capacity in Tons | | | | | |
|---|---|---|---|---|---|---|
| | 10 Feet | 12 Feet | 14 Feet | 16 Feet | 18 Feet | 20 Feet |
| Feet | Tons | Tons | Tons | Tons | Tons | Tons |
| 28 | 42 | 61 | 83 | ........ | ........ | ........ |
| 30 | 47 | 67 | 91 | ........ | ........ | ........ |
| 32 | 51 | 74 | 100 | 131 | ........ | ........ |
| 34 | 56 | 80 | 109 | 143 | ........ | ........ |
| 36 | 61 | 87 | 118 | 155 | 196 | ........ |
| 38 | 66 | 94 | 128 | 167 | 212 | ........ |
| 40 | 70 | 101 | 138 | 180 | 229 | 280 |
| 42 | ........ | 109 | 148 | 193 | 244 | 299 |
| 44 | ........ | 117 | 159 | 207 | 261 | 320 |
| 46 | ........ | ........ | 170 | 222 | 277 | 340 |
| 48 | ........ | ........ | ........ | 236 | 293 | 361 |
| 50 | ........ | ........ | ........ | ........ | 310 | 382 |

### TABLE 26
***Quantities for Concrete Silos—6-in. Walls**
**1:2:4 Walls and 1:2½:5 Floor and Footings; without Roof**

| Size Diameter x Height | Cement Bbls. | Sand Cu. Yds. | Stone or Pebbles Cu. Yds. |
|---|---|---|---|
| 10 x 25 ft. | 25.0 | 7.5 | 15.0 |
| 12 x 30 ft. | 36.0 | 11.0 | 22.0 |
| 12 x 35 ft. | 41.0 | 12.5 | 25.0 |
| 14 x 30 ft. | 42.5 | 13.0 | 26.0 |
| 14 x 35 ft. | 48.0 | 14.7 | 29.4 |
| 14 x 40 ft. | 54.5 | 16.5 | 33.0 |
| 16 x 40 ft. | 62.5 | 19.0 | 38.0 |
| 16 x 45 ft. | 69.0 | 21.0 | 42.0 |
| 18 x 45 ft. | 80.0 | 24.5 | 49.0 |
| 18 x 50 ft. | 86.5 | 26.5 | 53.0 |

*These quantities are approximate and intended for rough preliminary estimates.

**TABLE 27**

**Spacing of Horizontal Reinforcing Rods for Silos of Various Inside Diameters**

| Distance in feet down from top of Silo | 10-foot diameter | 12-foot diameter | 14-foot diameter | 16-foot diameter | 18-foot diameter | 20-foot diameter |
|---|---|---|---|---|---|---|
| | ⅜-inch Round Rods | ⅜-inch Round Rods | ½-inch Round Rods | ½-inch Round Rods | ½-inch Round Rods | ½-inch Round Rods |
| | Inches | Inches | Inches | Inches | Inches | Inches |
| Top 5 ft. | 24 | 24 | 24 | 24 | 24 | 24 |
| 5 to 10 | 24 | 24 | 24 | 24 | 24 | 24 |
| 10 to 15 | 24 | 18 | 24 | 24 | 24 | 24 |
| 15 to 20 | 18 | 16 | 24 | 18 | 18 | 16 |
| 20 to 25 | 16 | 12 | 18 | 16 | 14 | 14 |
| 25 to 30 | 14 | 10 | 16 | 14 | 12 | 12 |
| 30 to 35 | 12 | 9 | 14 | 12 | 10 | 10 |
| 35 to 40 | 10 | 8 | 12 | 10 | 9 | 8 |
| 40 to 45 | 9 | 7 | 11 | 9 | 8 | 7½ |
| 45 to 50 | 8 | 6½ | 10 | 8½ | 7½ | 7 |

Further information on silos will be gladly furnished by The Atlas Portland Cement Company.

## SMALL GRAIN ELEVATORS

A small concrete grain elevator is almost identical in construction with the ordinary concrete silo or circular tank. The only additions needed are a concrete pit for the bucket elevator boot and a work-house on top of the bin or bins to house the elevator head and chutes.

The operation of such an elevator is as follows: The farm wagon dumps its load of grain into the boot-pit and the bucket-elevator raises the grain to the top of the bin where it is discharged through the bin chute into the bin. When a railroad car is to be loaded the bin gate is opened and the grain flows into the pit from which the bucket elevator raises it to the top and it is discharged, this time through the car chute into the railroad car.

## SWIMMING POOLS

Towns and cities are building swimming and wading pools in athletic fields and parks for both adults and children. No other material is as suitable as concrete.

Swimming pools are built in various sizes, usually not smaller than 45 feet long by 15 feet wide. A common size and one which will fit the majority of cases is 60 feet long by 20 feet wide, a suggested design for which is shown in Fig. 81.

### Forms

Footing forms are first erected allowing sufficient space for tile drain around the outer edge of the pool as indicated in the drawing. The reinforcing is then placed for the walls and temporarily held by supports. Forms are then built for the entire height of the walls.

### Mixture and Placing

The mixture should be not leaner than 1:2:3. See page 27 on water-tight concrete. If the concreting operation cannot be completed in one continuous pouring without stopping, the walls should be divided by means of vertical stop-boards into sections which can be completed in one pouring without interruption.

The concrete must be especially well spaded next the inside form so as to prevent pockets and the concrete must be brought up uniformly at all points. Rapping the inside form with mallets, or better still, vibrating with pneumatic or electric hammer will be a great aid in securing a dense, smooth surface. After the interior forms have been removed the wedge shaped strips which will form a space to be filled with tar, are placed around the edge and construction of the floor carried on. If the floor cannot be placed continuously, the concrete should be laid in sections and joints provided. Floor construction is described on page 90.

### Reinforcement

Details on the placing and bonding of steel are given on pages 46 to 53.

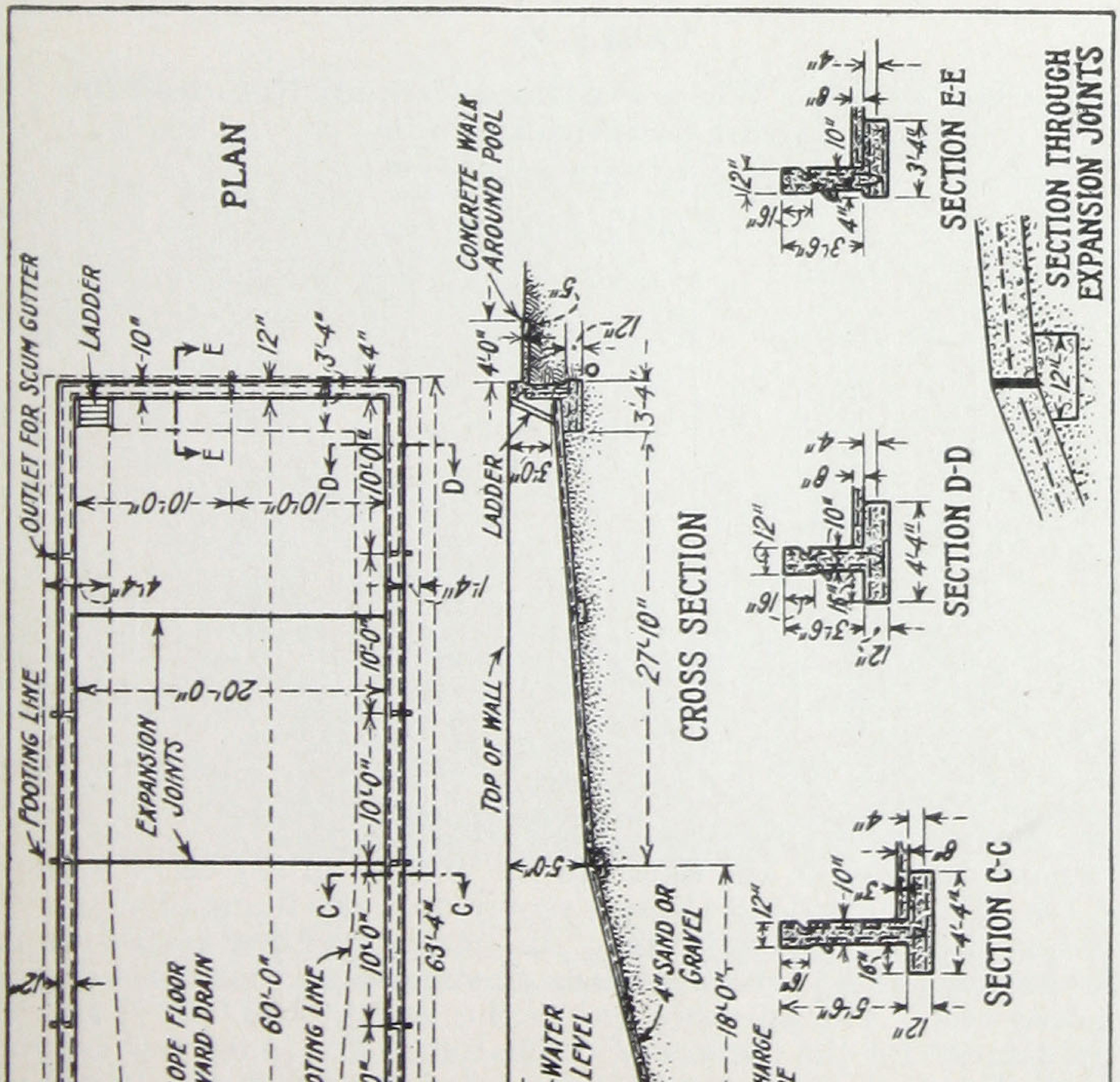



Fig. 81.—Construction details for typical 20′ x 60′ swimming pool.

## TABLE 28

### Quantities of Atlas White Portland Cement Required for Lining Swimming Pools

(For estimating purposes only)

Width (In Feet)

| Length in Ft. | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | bbls. | bbls. | bbls. | bbls. | bbls. | bbls. | bbls. | bbls. | bbls. | bbls. | bbls. | bbls. |
| 40 | 6.5 | 8.0 | 9.0 | 10.0 | 11.0 | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 50 | 8.0 | 9.5 | 10.5 | 12.0 | 13.5 | 14.5 | 16.0 | ...... | ...... | ...... | ...... | ...... |
| 60 | 9.5 | 11.0 | 12.5 | 14.0 | 15.5 | 17.0 | 18.5 | 20.0 | 21.5 | ...... | ...... | ...... |
| 70 | ..... | 12.5 | 14.0 | 16.0 | 17.5 | 19.5 | 21.0 | 23.0 | 24.5 | 26.5 | 28.0 | ...... |
| 80 | ..... | ..... | 16.0 | 18.0 | 20.0 | 22.0 | 24.0 | 25.5 | 27.5 | 29.5 | 31.5 | 33.5 |
| 90 | ..... | ..... | ..... | 20.0 | 22.0 | 24.0 | 26.5 | 28.5 | 30.5 | 33.0 | 35.0 | 37.0 |
| 100 | ..... | ..... | ..... | ..... | 24.5 | 26.5 | 29.0 | 31.5 | 34.0 | 36.0 | 38.5 | 41.0 |
| 110 | ..... | ..... | ..... | ..... | ...... | 29.0 | 31.5 | 34.0 | 37.0 | 39.5 | 42.0 | 44.5 |
| 120 | ..... | ..... | ..... | ..... | ...... | ...... | 34.5 | 37.0 | 40.0 | 42.5 | 45.5 | 48.0 |
| 130 | ..... | ..... | ..... | ..... | ...... | ...... | ...... | 40.0 | 43.0 | 46.0 | 49.0 | 52.0 |

The quantities given in the table are the number of barrels (4 bags per bbl.) of Atlas White Portland Cement required for the lining of a standard swimming pool of the size indicated. In computing these quantities the pool was assumed to be three feet deep at one end and nine feet deep at the opposite end. The amounts are to the nearest half barrel and are only approximate for the purpose of estimating. The lining was assumed to be applied ½ inch thick, made of a mortar consisting of 1 part Atlas White to 2½ parts of selected sand.

## Finish

If weather conditions allow the inner forms to be removed within 24 hours, the concrete can be roughened with a wire brush and surfaced with a mortar composed of 1 part Atlas-White Cement, and 2 parts white sand, or crushed marble. If the forms are allowed to remain for a longer time, the surface should be thoroughly roughened with a stone pick or similar tool before applying the finish. Such a finish has a very attractive appearance; see pages 36 to 39 on surface finishes.

In order to eliminate the time and labor required for plastering the inside of a swimming pool, it is becoming more and

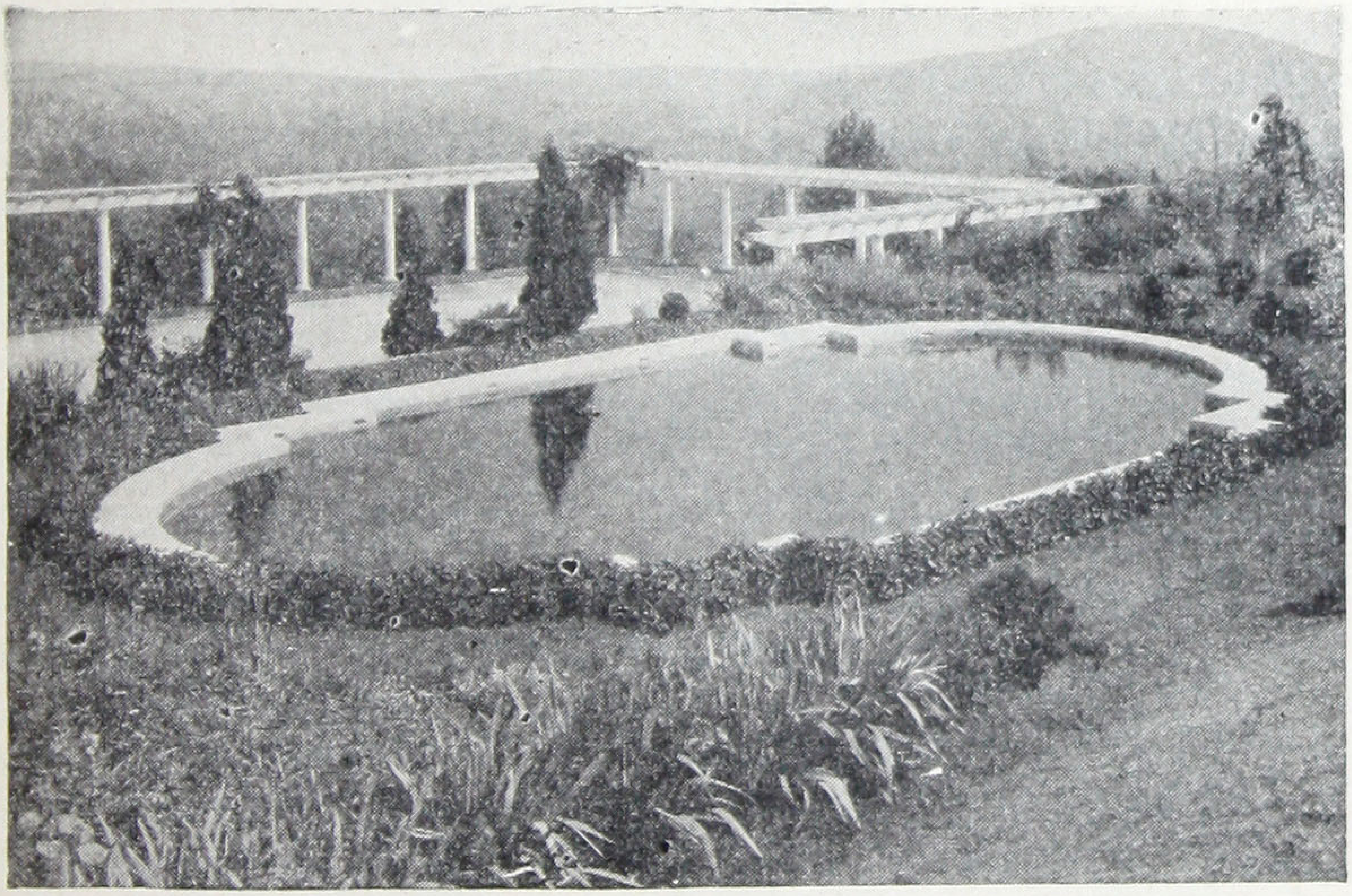


Fig. 82.—An example of a beautiful ornamental swimming pool executed with Atlas White Portland Cement. A swimming pool need not be rectangular in shape, although the same reinforcing details shown in Figure 81 can be used, providing the depth of water is the same.

more the practice to use Atlas White Portland Cement throughout the walls and floor. This gives a monolithic white concrete and the extra cost of the white cement is offset by the saving in labor which would have been needed for preparing the surface and plastering with white mortar. There is the added advantage of having the pool of monolithic poured construction.

It is advisable to wait at least 3 weeks before back filling with earth, or allowing the tank to be filled with water. Further details on construction of swimming pools will be gladly furnished by The Atlas Portland Cement Company.

## STORAGE CELLARS

Storage cellars are usually built underground or two-thirds underground with either a flat or an arched roof.

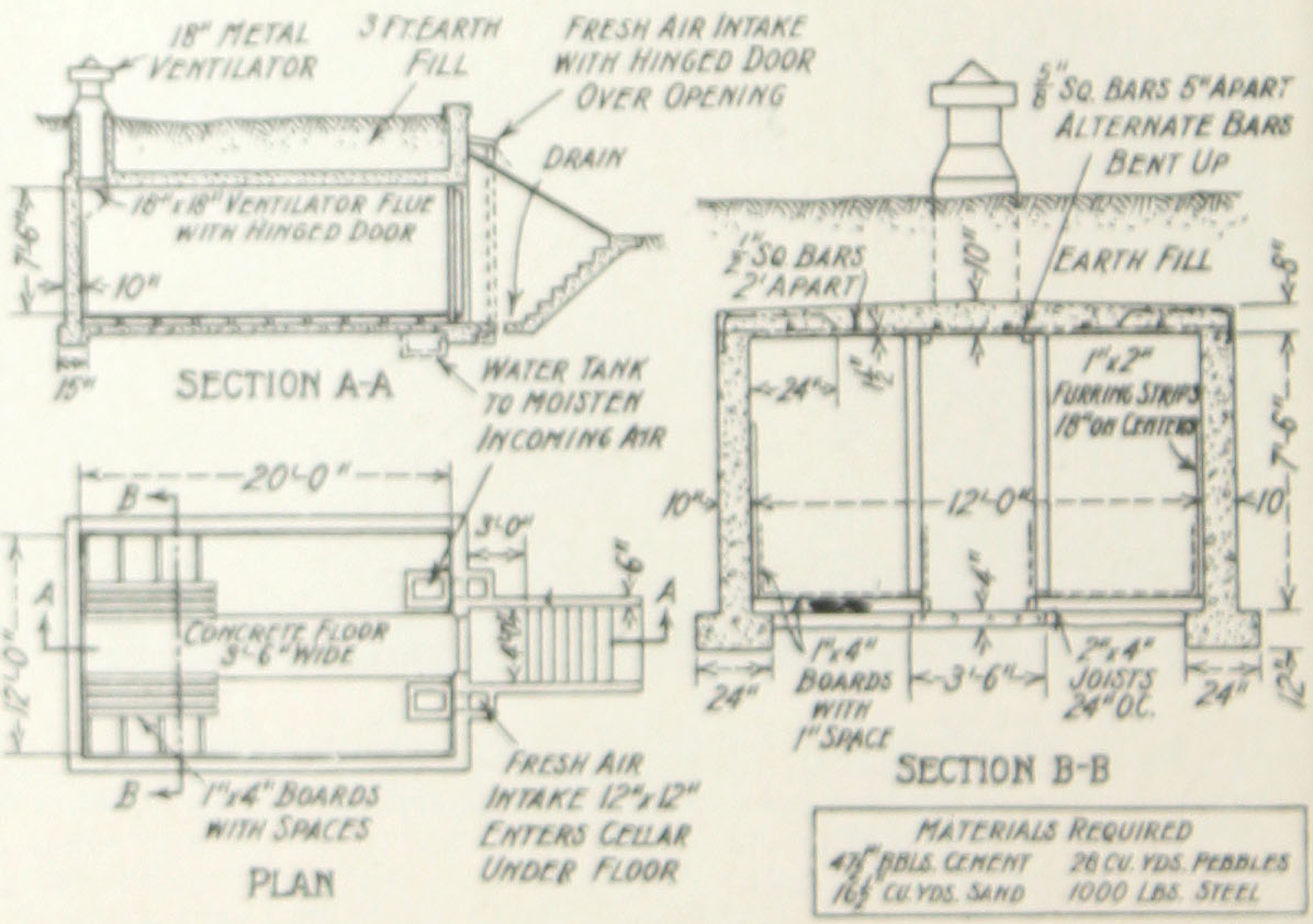



Fig. 83.—Details of concrete storage cellar construction.

### Forms

The principles of form construction are described in Chapter III beginning on page 54 and apply to the building of storage cellars. The construction of forms for the arched roof is more complicated than for a flat top and plans may be secured by writing to The Atlas Portland Cement Company.

### Construction

Construction details are shown in Figure 83. The concrete should be mixed in the proportion of 1:2:4 except for the arched roof which should be 1:2:3.

The concrete should be well puddled in the forms and spaded next to the surface, especially if the storage cellar is partly above ground, so as to provide a good surface.

## Roof

Reinforcing steel must be used in the roof of a cellar with a flat top. For a cellar such as that shown in Fig. 83, bars ⅝-inch square are spaced 5 inches apart, center to center, and placed 1½ inches from the bottom of the slab. Alternate bars are bent up at a point 2 feet from the inside cellar wall. The ends of all bars are bent at right angles to form a hook about 3 inches long. This insures good anchorage in the concrete. One-half inch square bars placed 2 feet apart are run lengthwise.

# SEPTIC TANKS

A concrete septic tank is a modern and sanitary means of disposing of sewage and household waste. It is made usually with two compartments.

Fig. 84 shows the general layout, and Figures 85 and 86 show plans of septic tanks which are designed to take care of the requirements of the average household.

DIMENSIONS OF SEPTIC TANKS

| Maximum Number of Persons Served | Capacity in Gallons | Dimensions A | | B | | C | | D | | E | | F | Suggested Length of Tile System Open Soil | Tight Soil |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Ft. | Ft. | Ft. |
| 5 | 250 | 2 | | 4 | | 5 | | 2 | 2 | 2 | 6 | 1 | 150 | 250 |
| 10 | 500 | 3 | | 5 | 4 | 5 | | 3 | | 2 | 6 | 1 | 300 | 500 |
| 15 | 750 | 3 | 6 | 6 | 10 | 5 | | 3 | 8 | 2 | 6 | 1 | 450 | 750 |
| 20 | 1000 | 4 | – | 8 | | 5 | | 3 | 10 | 2 | 8 | 1 | 600 | 1000 |
| 25 | 1250 | 4 | 6 | 9 | | 5 | | 4 | 3 | 2 | 8 | 1 | 750 | 1250 |

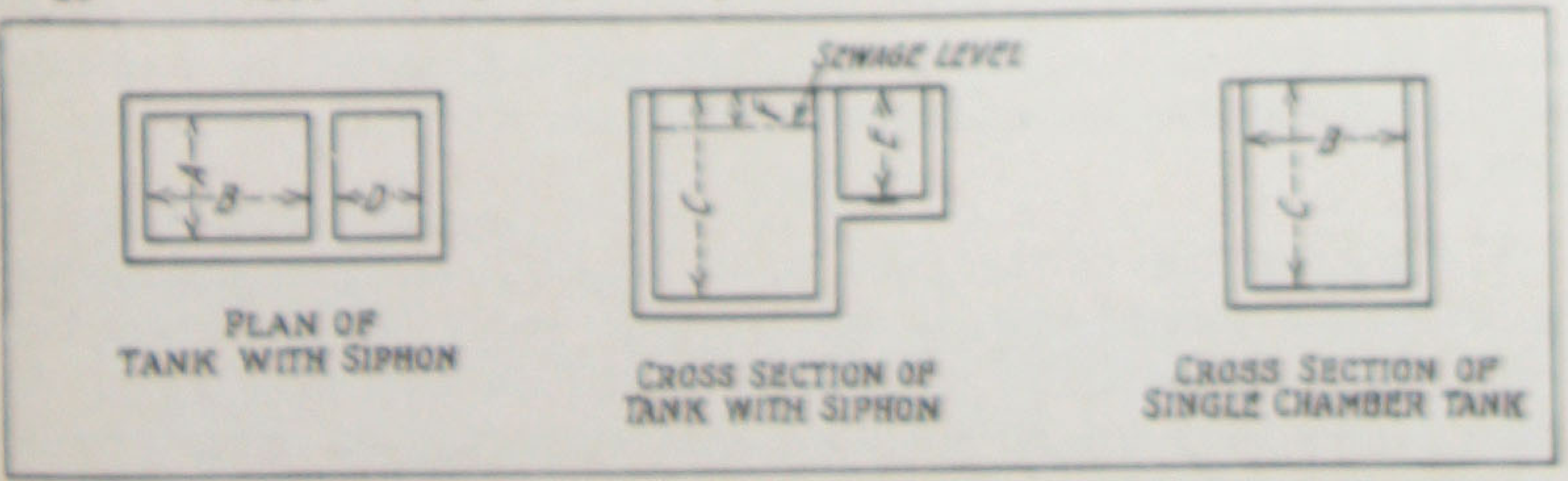



Fig. 84.—Layout diagrams showing sizes for septic tanks depending on number of persons served.

## Forms

The general principles of form construction are described in Chapter III beginning on page 54, and these apply to the building of septic tanks.

## Mixture and Placing

The mixture should be 1:2:3. If possible the concrete should be placed continuously so as to avoid joints. It should be well spaded and thoroughly worked in and around the reinforcement. Size of the pebbles or crushed stone for this class of work usually runs from ¼-inch to 1¼-inches.

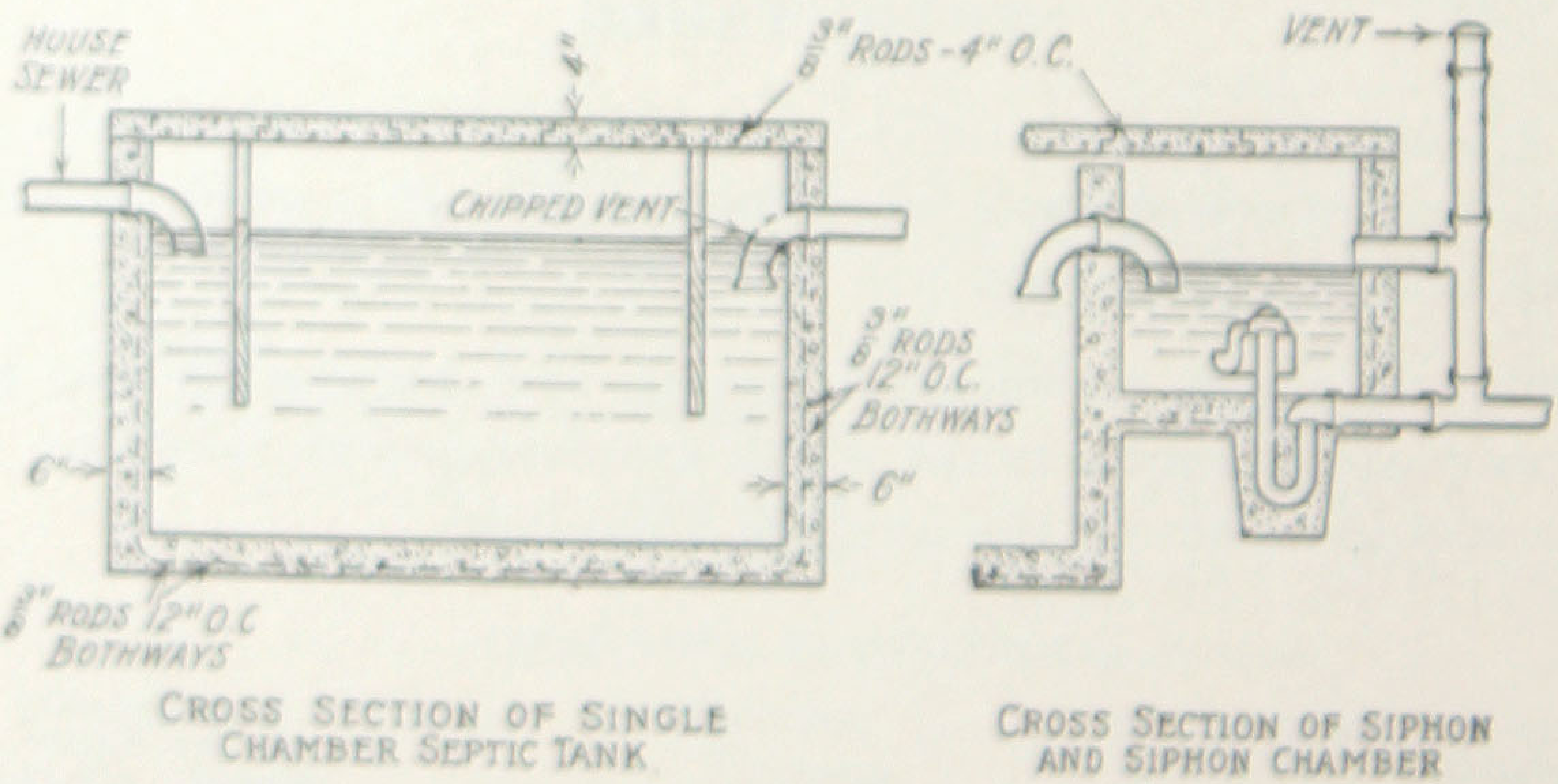



Fig. 85.—Cross section of septic tank showing siphon chamber which may be added if desired. Intermittent discharge by means of a siphon is preferable.

## Reinforcement

Rods or heavy wire mesh may be used for reinforcing. Fig. 85 shows size and spacing. Reinforcement must be securely tied so as not to be pushed out of place when the concrete is poured.

The roof or top of the tank must be built sufficiently strong to resist the weight that it will have to carry. Sometimes the tanks are underground and have earth on top of them. At other times they are so situated that they will be driven over, and must be designed to support loads accordingly. A manhole should be provided for cleaning purposes.

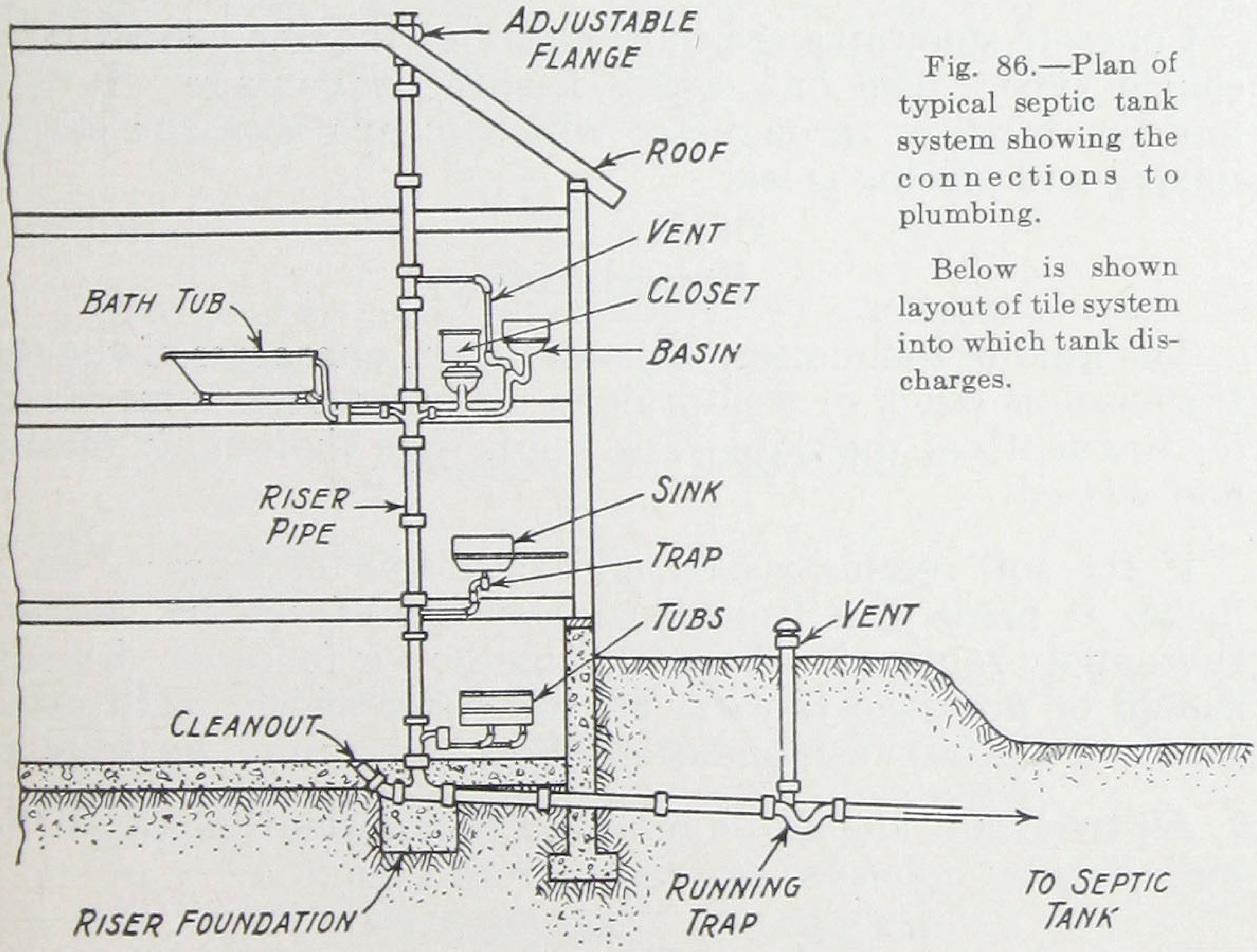
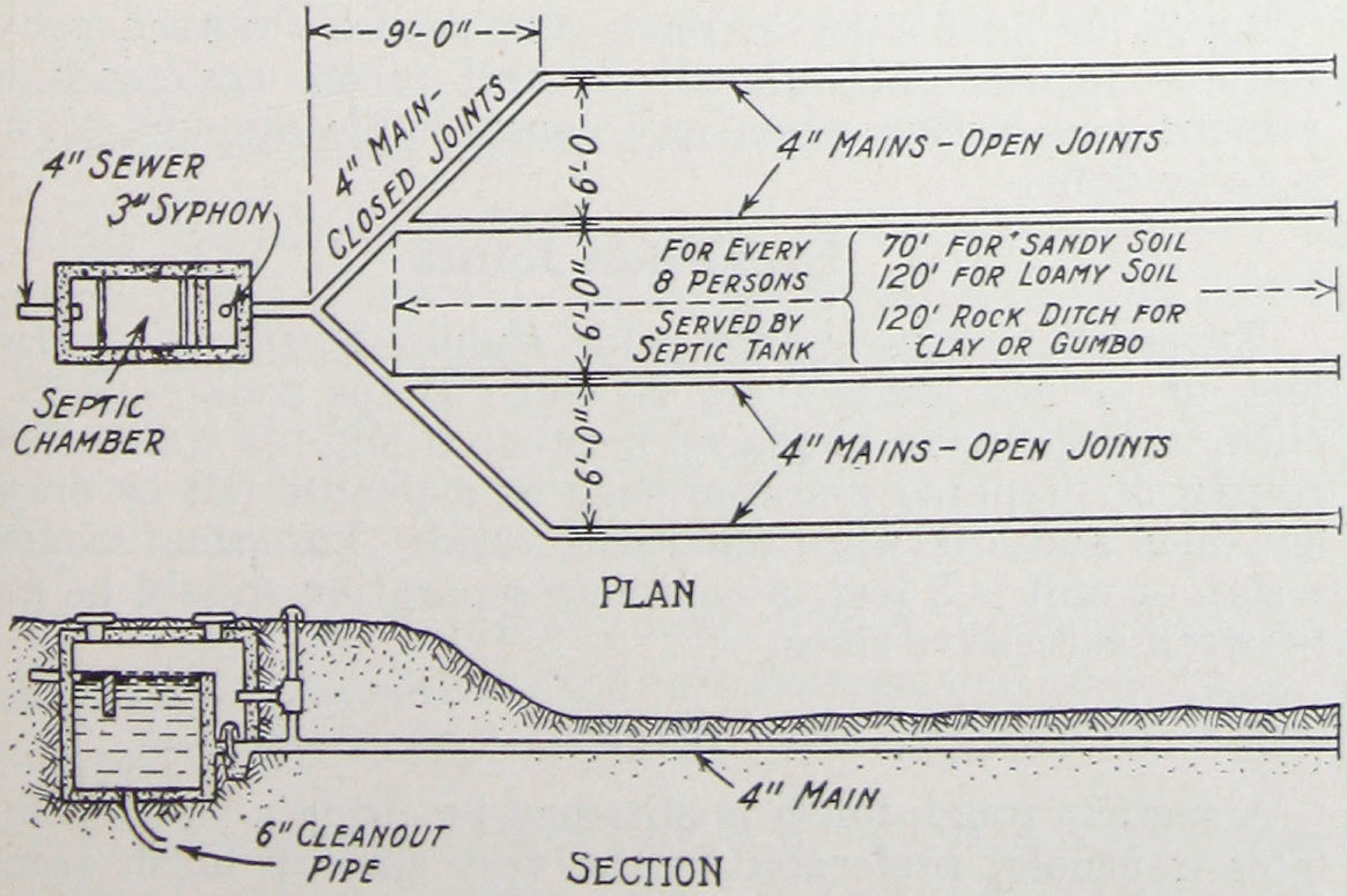



Fig. 86.—Plan of typical septic tank system showing the connections to plumbing.

Below is shown layout of tile system into which tank discharges.



## SIDEWALKS

Concrete sidewalks are built either of the one course or two course type. The one course has the advantage. It is of uniform mixture throughout, which means that the cost of mixing and placing is less.

### Foundations

The kind of foundation depends on the character of the soil. If the soil is sandy or well-drained, an excavation is made only for the depth of the slab. The soil is then thoroughly tamped and wetted.

If the soil retains water, an excavation of from 10 to 12 inches is made and from 6 to 8 inches of cinders laid and thoroughly rammed. When this method is followed, drainage should be provided to carry off the water which might otherwise remain in the foundation and cause injury by freezing.

All tree roots should be removed to sufficient depth so that no injury by upheaval can result from them.

### Forms

2 x 4's or 2 x 6's set in place and securely staked provide suitable forms. Manufactured steel forms are more convenient and lasting when any considerable amount of work is to be done.

### Expansion Joints

Expansion joints ½-inch wide should be placed every 50 feet, or ¼-inch joints every 25 feet. If the walk runs to the curb, a joint should be placed between it and the walk. Joints consist of prepared material such as asphaltic felt or may be left open and afterward filled with sand. The usual length of a slab or unit is 5 feet; a complete separation should be made between successive slabs.

### Finish

A slightly rough finish is obtained by using a wooden float. This is usually preferable to the very smooth finish secured by using a steel trowel.

Excess water should be avoided, see page 10; also excessive troweling, which brings the cement and water to the surface and causes dusting with the result that the sidewalk will not wear as well as it would otherwise.

### Protection

The concrete should be protected by covering or sprinkling so as to prevent too rapid drying out.

### Mixture and Thickness

One-course sidewalk is built of a mixture of 1:2:3 and is usually 4 or 5 inches thick.

Two-course sidewalk is built of 1:2½:5 for the base; and one part Atlas Cement and 2 parts sand for the top. The base is commonly 4 inches thick, and top 1 inch thick.

## CURBS AND GUTTERS

Concrete is the material commonly used for curb and gutter construction. It is adaptable to any form or shape, and can be built at the same time as a driveway or pavement.

Both two-course and one-course construction are used, the tendency now is toward one-course work—the same mixture throughout. It is easier and more economical to handle. A good finish can be obtained by properly tamping and spading the concrete and then removing the forms as soon as possible and troweling or rubbing the surface.

The single curb is usually built 6 to 8 inches thick at the top and 9 to 12 inches thick at the bottom, and 18 to 24 inches deep. Fig. 87a shows how forms are constructed and braced.

Fig. 87b shows the size of curb and construction of forms for combined curb and gutter; also for curb combined with con-

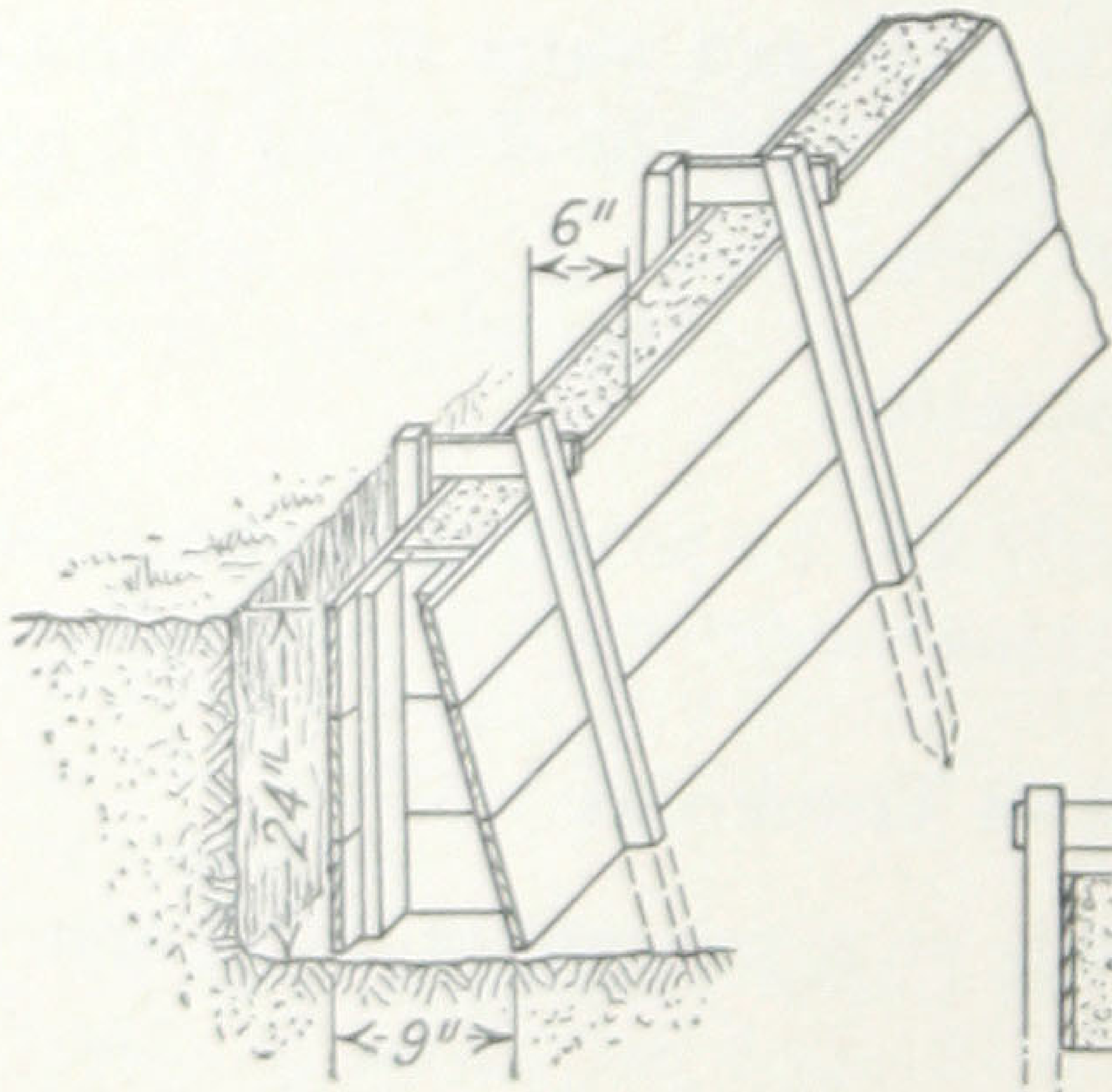



Fig. 87A.—At left is shown wood forms for plain concrete curb.

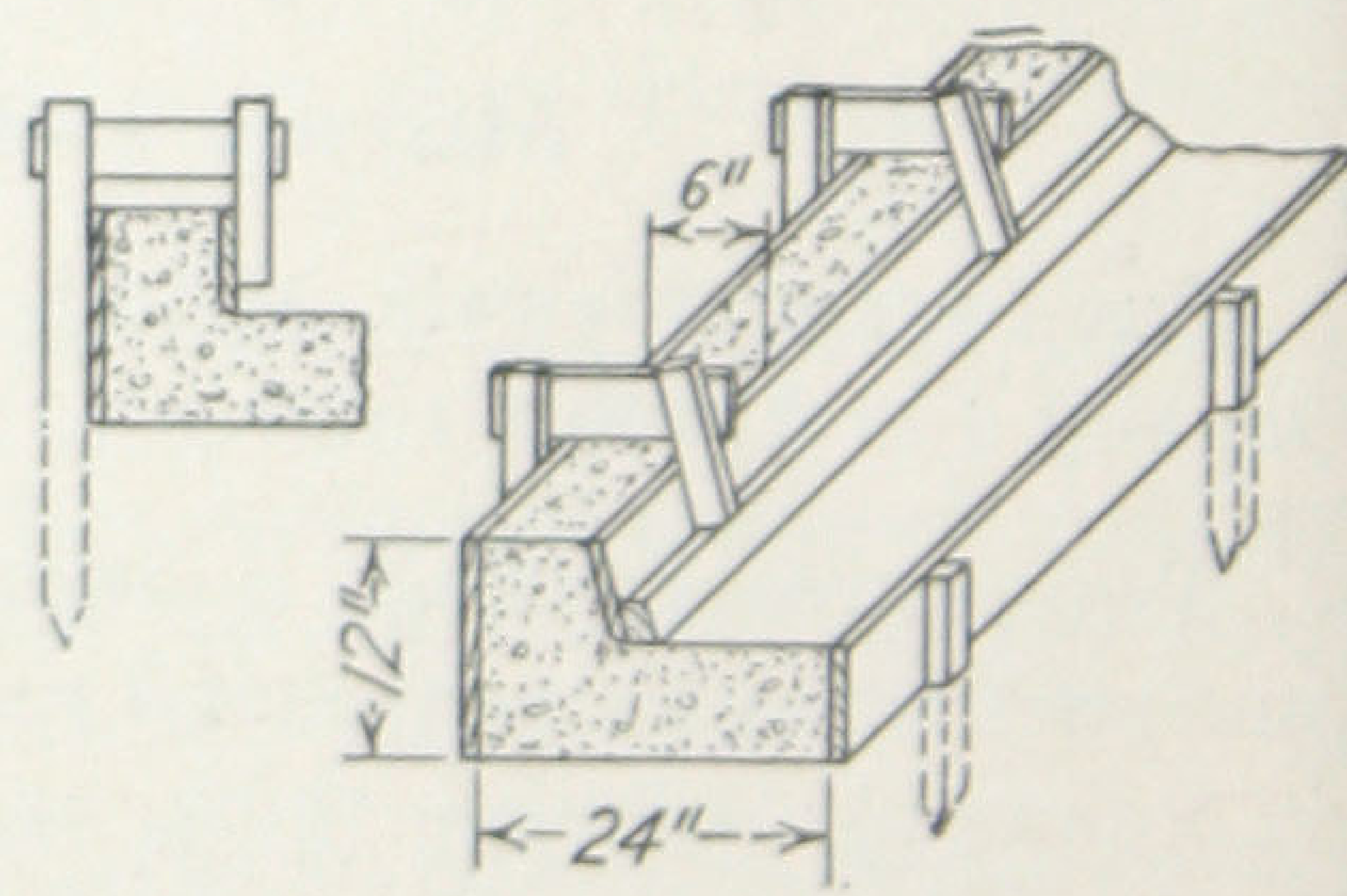


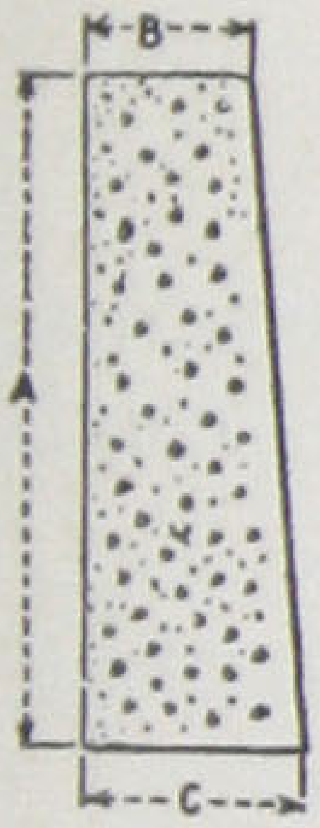

Fig. 87B.—Wooden forms for combined curb and gutter. It is usually best to employ manufactured steel molds for this type of curb.

crete driveway. Manufactured steel forms for curbs are much superior to wood forms.

If soil requires a sub-base, gravel or cinders to a thickness of 6 inches may be used. The concrete should consist of 1:2:3 mixture with particles not larger than 1½ inches for one-course work.

Expansion joints are provided by inserting prepared sheets of asphaltic felt, allowing a joint of at least ½ inch every 50 feet. The curb should be built in sections as in sidewalk construction by using a steel dividing plate at intervals of not more than 10 feet.

Both the curb shown in Fig. 87a and the curb and gutter shown in Fig. 87b have the same cross-section area. Hence, the quantities required per 100 lineal feet are the same—7 barrels cement, 2 cubic yards sand, 4 cubic yards pebbles.

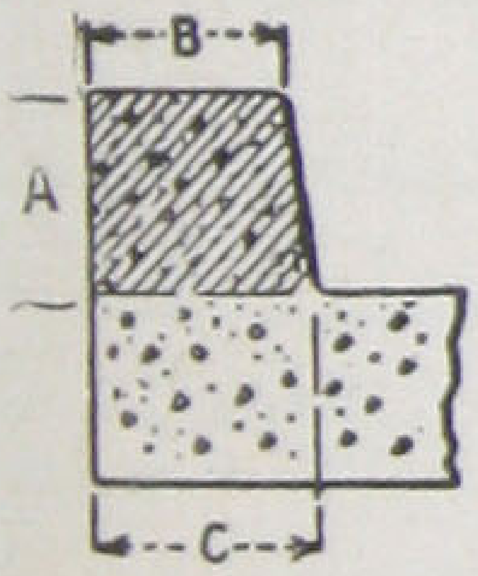



## TABLE 29

### Table of Quantities for Curbs and Gutters for Each 100 Feet of Length

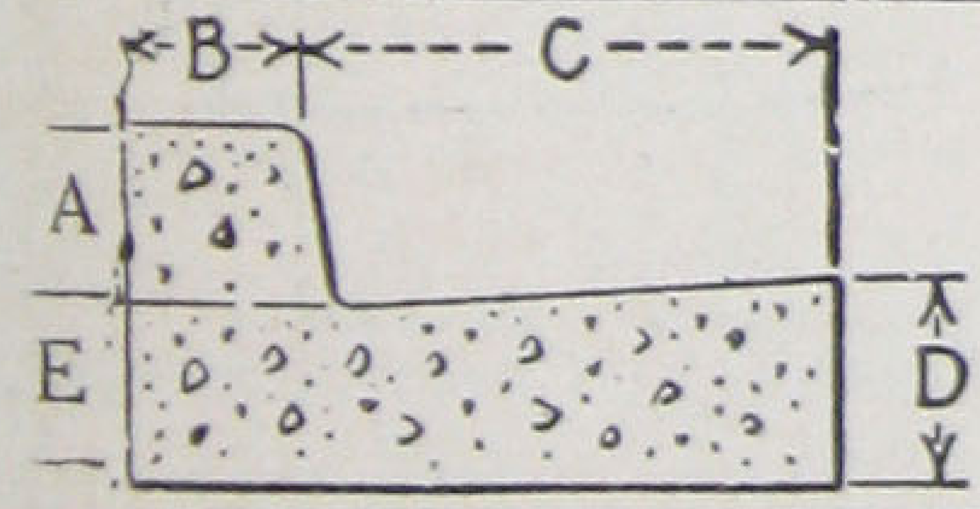
### SEPARATE CURB

| A | B | C | 1:2:3 Mix* | | | 1:2:4 Mix | | | †1:2½:5 Mix | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ins. | Ins. | Ins. | Cement bbls. | Sand cu. yds. | Stone cu. yds. | Cement bbls. | Sand cu. yds. | Stone cu. yds. | Cement bbls. | Sand cu. yds. | Stone cu. yds. |
| 24 | 6 | 8 | 7.50 | 2.25 | 3.34 | 6.50 | 1.95 | 3.86 | 5.37 | 2.00 | 3.98 |
| 30 | 6 | 8½ | 9.73 | 2.91 | 4.31 | 8.45 | 2.52 | 4.99 | 6.94 | 2.58 | 5.15 |
| 36 | 6 | 9 | 12.10 | 3.61 | 5.35 | 10.50 | 3.12 | 6.18 | 8.61 | 3.19 | 6.39 |




### INTEGRAL CURB

| A | B | C | 1:1½:3 Mix | | | 1:2:3 Mix | | | 1:2:4 Mix | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ins. | Ins. | Ins. | Cement bbls. | Sand cu. yds. | Stone cu. yds. | Cement bbls. | Sand cu. yds. | Stone cu. yds. | Cement bbls. | Sand cu. yds. | Stone cu. yds. |
| 6 | 6 | 7 | 1.91 | 0.42 | 0.85 | 1.74 | 0.52 | 0.77 | 1.51 | 0.45 | 0.89 |




### COMBINED CURB AND GUTTER

| A | B | C | D | E | 1:2:3 Mix* | | | 1:2:4 Mix | | | †1:2½:5 Mix | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ins. | Ins. | Ins. | Ins. | Ins. | Cement bbls. | Sand cu. yds. | Stone cu. yds. | Cement bbls. | Sand cu. yds. | Stone cu. yds. | Cement bbls. | Sand cu. yds. | Stone cu. yds. |
| 6 | 6 | 18 | 7 | 6 | 8.70 | 2.60 | 3.85 | 7.55 | 2.25 | 4.45 | 6.20 | 2.30 | 4.60 |
| 6 | 6 | 24 | 7½ | 6 | 10.80 | 3.22 | 4.77 | 9.35 | 2.79 | 5.52 | 7.68 | 2.85 | 5.70 |

*A 1:2:3 mix is much used for curb work, especially where no plastering of the surface is allowed.

†The leaner 1:2½:5 mix is generally employed for curbs which will be finished by a mortar plaster coat. This practice is now not favored by many persons, but where it is allowed an additional allowance should be in the estimate for the cement used in the plastered coat

## CONCRETE DRIVEWAYS

Concrete is used for driveways to garages, around the house and barns, and about industrial plants, also for alleys, roads and pavements generally.

This construction is permanent, non-slippery, dustless, uniform of surface, easily cleaned and reasonable in cost.

Fig. 88 shows cross-sections for the three different types of driveway construction.

The mixture used is 1:2:3.

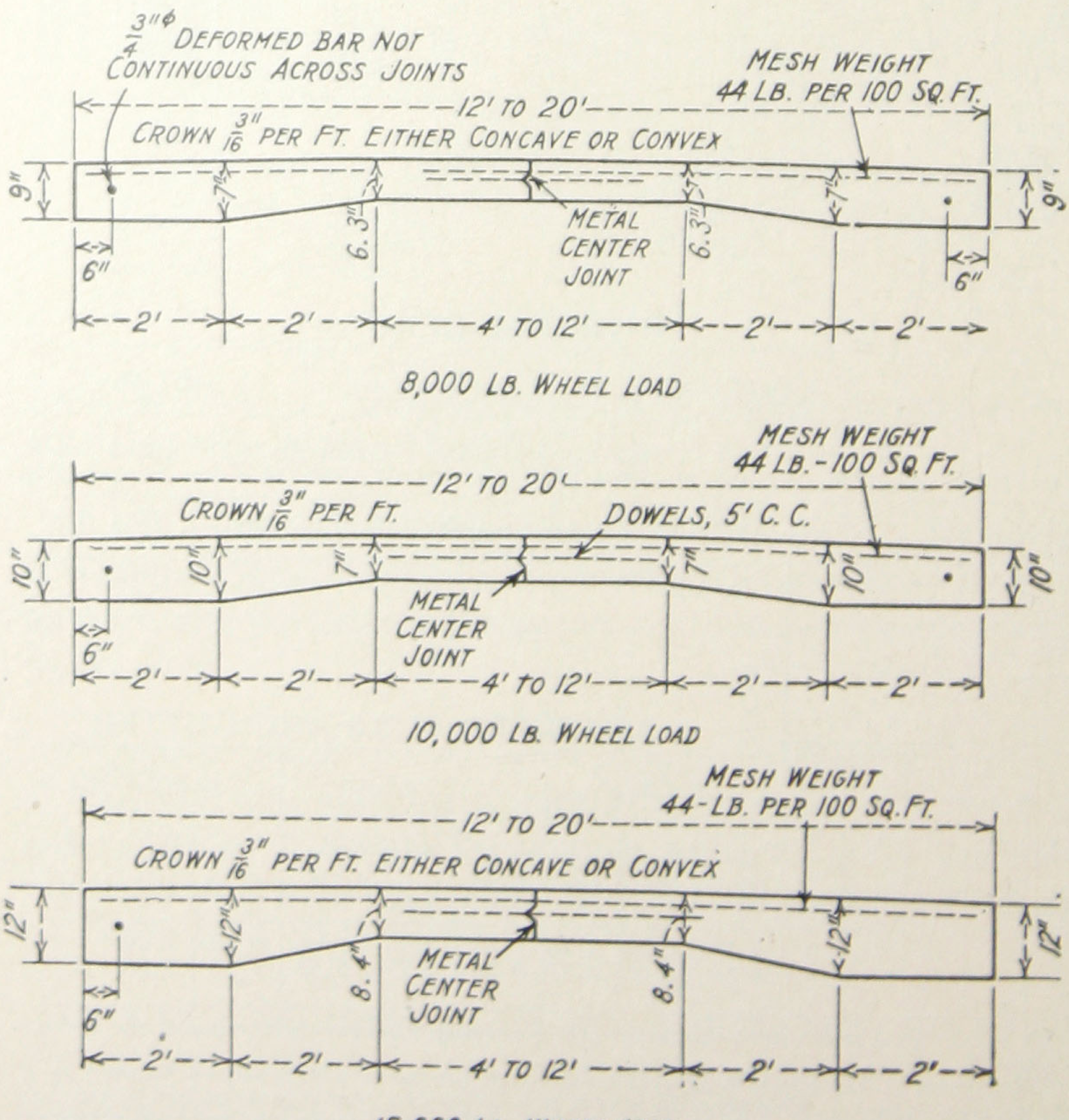



Fig. 88.—Cross sections of concrete driveways for various loads.

## TABLE 30

### Quantities for Concrete Roads and Pavements

| Width in Feet | Square Yards per Mile | Thickness | | Cubic Yards Concrete per Linear Foot of Pavement | Material Required per Linear Foot of Pavement—1:2:3 Mix | | |
|---|---|---|---|---|---|---|---|
| | | Sides, Inches | Center, Inches | | Cement Barrels | Sand Cubic Yards | Stone or Pebbles Cubic Yards |
| 9 | 5,280 | 6 | 8 | .204 | .355 | .106 | .157 |
| 10 | 5,867 | 6 | 8 | .227 | .394 | .118 | .175 |
| 16 | 9,387 | 6 | 8 | .362 | .630 | .188 | .279 |
| 16 | " | 7 | 9 | .411 | .715 | .214 | .316 |
| 16 | " | 8 | 10 | .461 | .802 | .240 | .355 |
| 18 | 10,560 | 6 | 8 | .407 | .708 | .212 | .313 |
| 18 | " | 7 | 9 | .463 | .806 | .241 | .357 |
| 18 | " | 8 | 10 | .519 | .903 | .270 | .400 |
| 20 | 11,733 | 6 | 8 | .453 | .788 | .235 | .349 |
| 20 | " | 7 | 9 | .514 | .887 | .265 | .393 |
| 20 | " | 8 | 10 | .576 | 1.002 | .300 | .444 |
| 24 | 14,080 | 6 | 8 | .543 | .945 | .282 | .418 |
| 24 | " | 7 | 9 | .617 | 1.074 | .321 | .475 |
| 24 | " | 8 | 10 | .691 | 1.202 | .359 | .532 |

### Quantities for 1000 Square Yards Concrete Base for Pavements

#### UNIFORM THICKNESS THROUGHOUT

| Thickness of Base | Cubic Yards of Concrete per 1,000 Sq. Yds. of Pavement | MIX | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1:2:4 | | | 1:2½:5 | | | 1:3:6 | | |
| | | Cement Bbls. | Sand Cu. Yds. | Stone Cu. Yds. | Cement Bbls. | Sand Cu. Yds. | Stone Cu. Yds. | Cement Bbls. | Sand Cu. Yds. | Stone Cu. Yds. |
| 5 in. | 139 | 210 | 62 | 124 | 172 | 64 | 128 | 147 | 65 | 135 |
| 6 " | 167 | 252 | 75 | 149 | 206 | 77 | 153 | 177 | 78 | 157 |
| 7 " | 194 | 294 | 87 | 173 | 241 | 89 | 179 | 206 | 91 | 183 |
| 8 " | 222 | 335 | 100 | 198 | 275 | 104 | 204 | 235 | 104 | 209 |

### Quantities for 1000 Square Yards Concrete Roads and Pavements

#### CROWNED SURFACE

| Thickness | | Average Thickness | Cu. Yds. of Concrete per 1,000 Sq. Yds. of Pavem't | MIX | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1:1½:3 | | | 1:2:3 | | | 1:2:4 | | |
| Sides | Center | | | Cement Bbls. | Sand Cu. Yds. | Stone Cu. Yds. | Cement Bbls. | Sand Cu. Yds. | Stone Cu. Yds. | Cement Bbls. | Sand Cu. Yds. | Stone Cu. Yds. |
| 5 in. | 7 in. | 6.33 in. | 176 | 336 | 74 | 150 | 306 | 91 | 136 | 266 | 79 | 157 |
| 5 " | 7½ " | 6.67 " | 185 | 353 | 78 | 157 | 322 | 96 | 143 | 279 | 83 | 165 |
| 6 " | 8 " | 7.33 " | 204 | 389 | 86 | 174 | 355 | 106 | 157 | 308 | 91 | 182 |
| 6 " | 8½ " | 7.67 " | 213 | 406 | 89 | 181 | 370 | 111 | 164 | 321 | 95 | 190 |
| 7 " | 9 " | 8.33 " | 231 | 441 | 97 | 196 | 402 | 120 | 178 | 348 | 103 | 206 |
| 7 " | 9½ " | 8.67 " | 241 | 460 | 101 | 205 | 420 | 125 | 186 | 364 | 109 | 215 |
| 8 " | 10 " | 9.33 " | 259 | 495 | 109 | 220 | 450 | 135 | 200 | 391 | 116 | 231 |
| 8 " | 10½ " | 9.67 " | 269 | 514 | 113 | 229 | 468 | 140 | 207 | 406 | 120 | 240 |

## ENGINE FOUNDATIONS

Engine foundations of concrete are strong, rigid and permanent.

A good solid footing must be obtained so that no settlement of the foundation can take place. The foundation itself must be large and massive enough to hold the engine firmly without vibration.

The form is really a bottomless box, shown in Fig. 89. Bolts for fastening the engine to the foundation are held in place by means of a template, also shown in Fig. 89.

Bolts should extend at least a foot into the concrete and have large iron washers at the lower end. Pieces of pipe at least twice the diameter of the bolts allow for a slight adjustment. After the bolts are in position the spaces between them and the pipe are filled with a 1:1 mortar. The mixture for the foundation should be 1:2:4. The concrete should harden at least a week before placing the engine on the foundation, and two weeks should elapse before the engine is allowed to run.

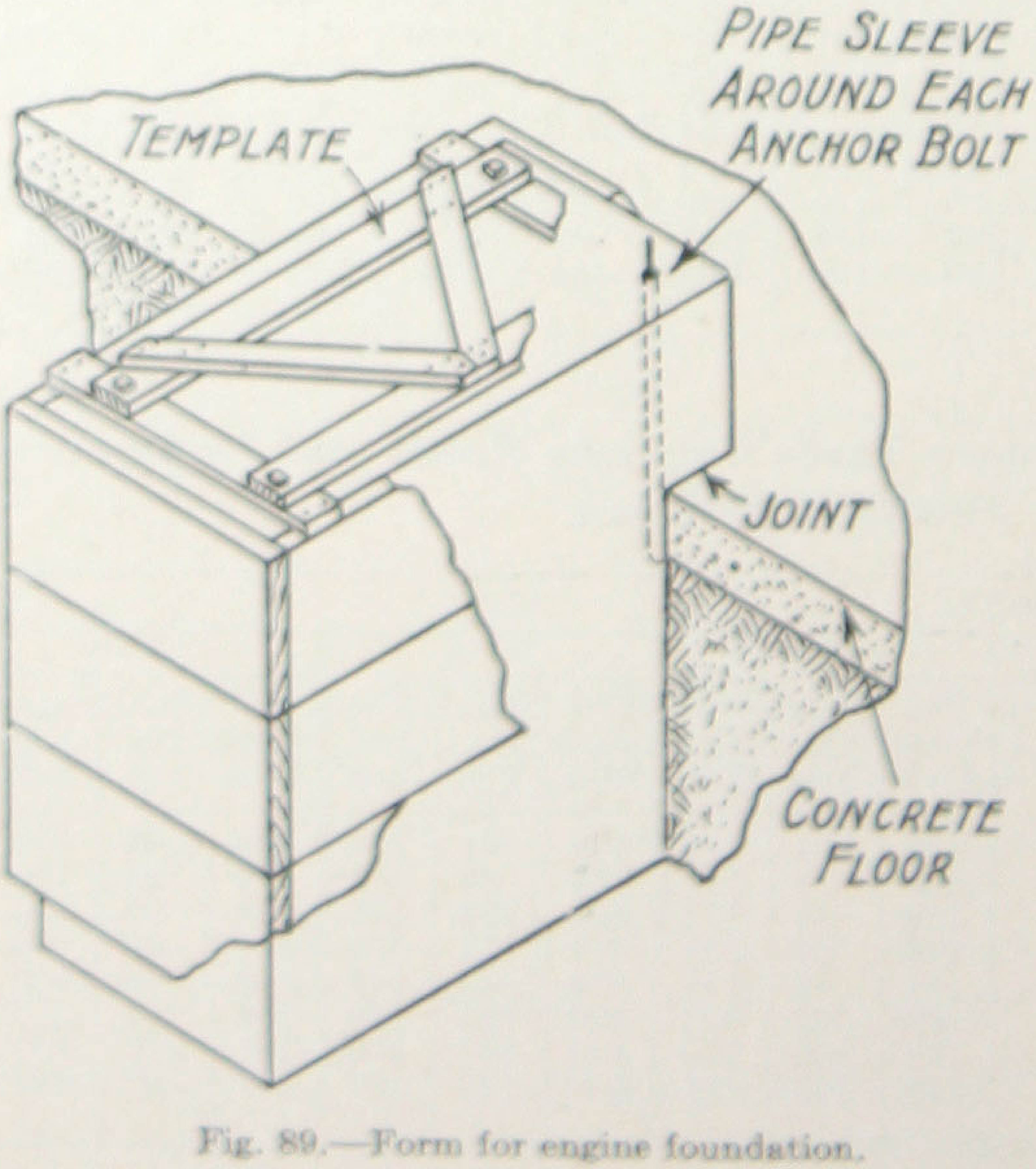



Fig. 89.—Form for engine foundation.

When this period of time cannot be allowed, use Atlas Lumnite Cement (see page 147) which permits the foundation to be used in 24 hours.

## CULVERTS AND SMALL BRIDGES

Culverts to be satisfactory must be strong, lasting, free from repairs and decay. No other material meets these requirements so well as concrete. Size may be determined by measuring the width and depth of the stream during high water, and comparing the results arrived at, if possible, with

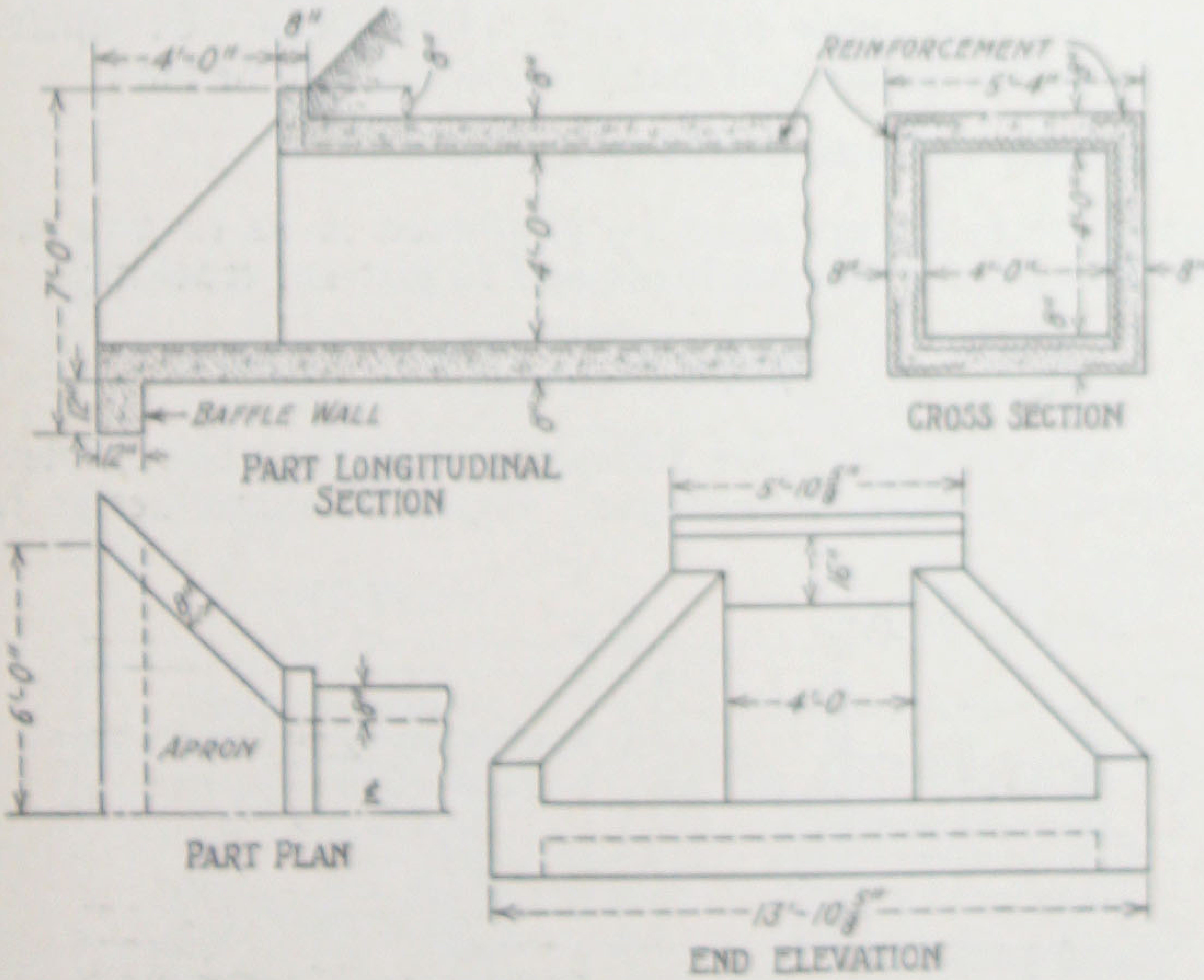



Fig. 90.—Plans for small box culvert.

culverts over the same stream in the same neighborhood. The opening of a culvert should be sufficient to take care of the flow during high water.

For small openings concrete pipe is generally used. In the case of larger openings the box or arch culvert is the best. A slope of $\frac{1}{4}$-inch per foot in the direction of flow is sufficient for the floor of the culvert.

## Box Culverts

Box culverts are built of square or rectangular cross-sections. Fig. 90 shows a good design for a box culvert. It is of square section, with bottom baffle wall and apron at each end to prevent undermining.

Forms for box culverts are very simple and can be built by following the general directions on pages 54 to 85. The outside forms are set up first, then concrete poured for the bottom, and the inside forms next set in place. Collapsible forms represent economy if many culverts are to be built.

Mixture for culverts should be 1:2:4.

Box culverts always must be reinforced so as to give adequate strength for bearing loads and to prevent cracking.

## Arch Culverts

Arch culverts, while more difficult to build than box culverts, have certain obvious advantages. Figure 91 shows design for

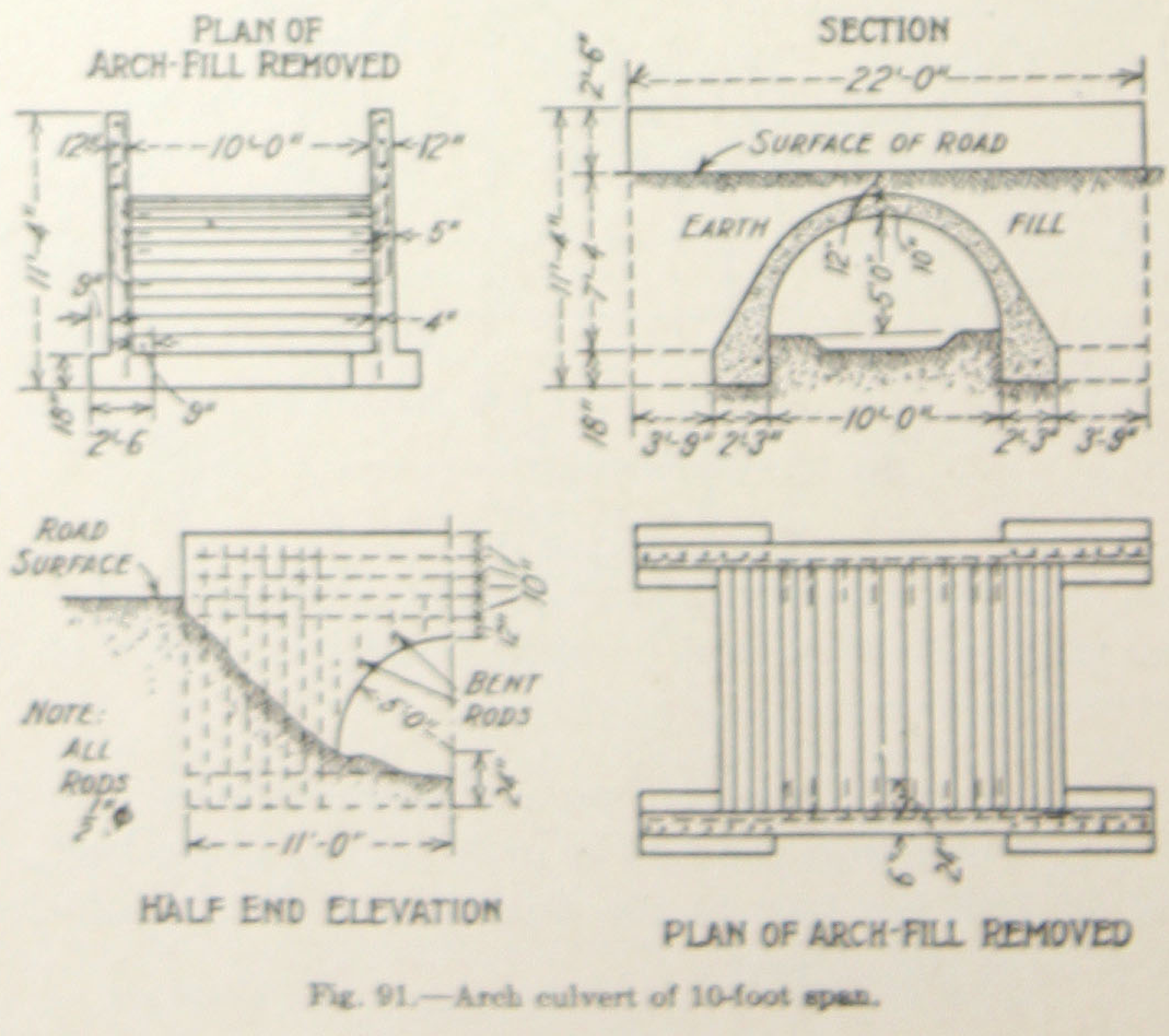



Fig. 91.—Arch culvert of 10-foot span.

culvert of ten foot clear span where soil is solid and firm. such as hardpan or hard clay.

Forms are made as shown in Fig. 92. For further information on forms see pages 54 to 85.

If good aggregates are obtainable, the mixture may consist of 1:2:4. Reinforcement must be carefully placed as shown, and held rigidly in position.

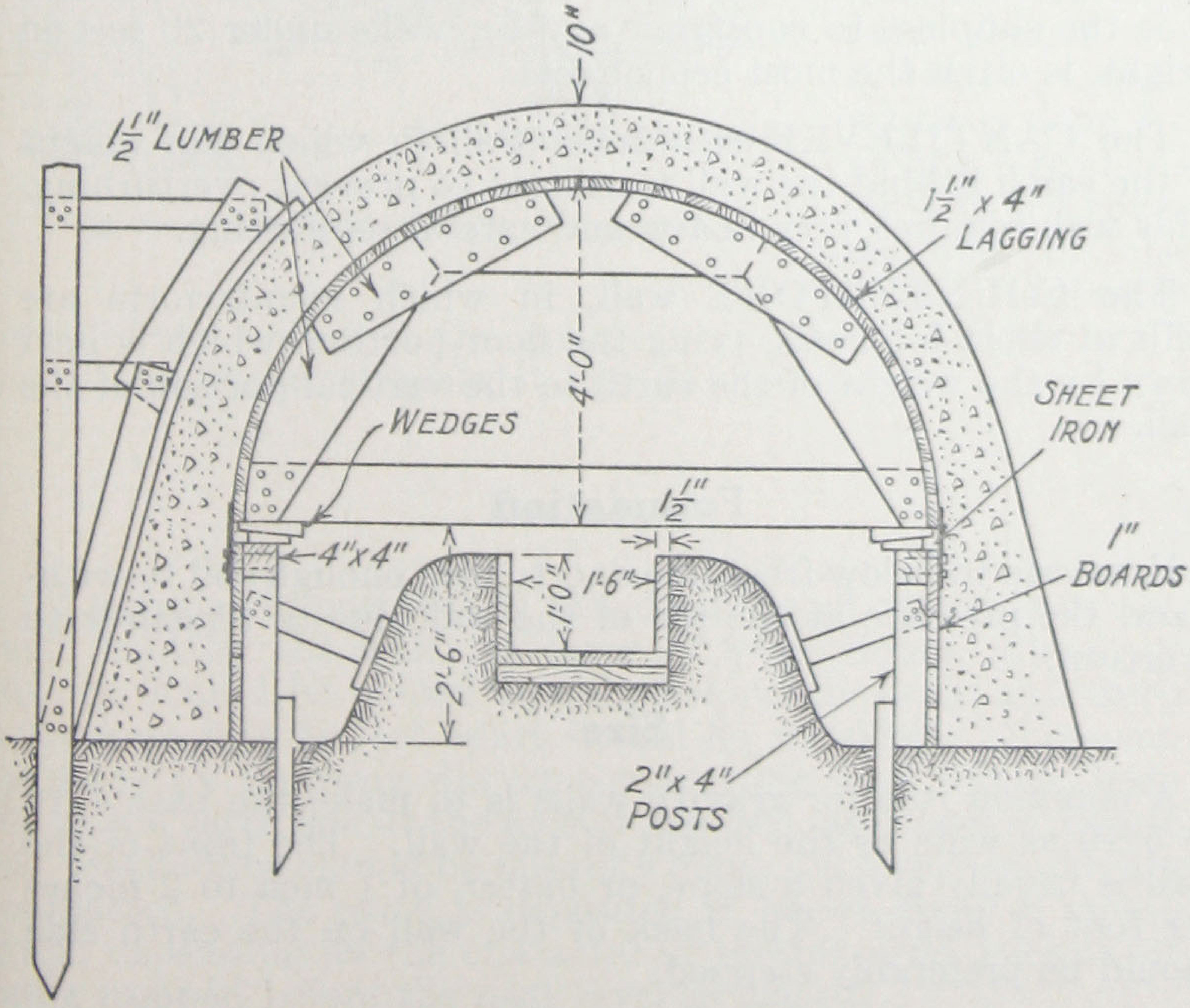



Fig. 92.—Typical centering for small arch culvert. The details of this centering can be altered to meet local conditions. For larger arches it is wise to provide center posts for additional support.

## CONCRETE RETAINING WALLS

On account of the low cost, great strength and adaptability of concrete, retaining walls are usually built of this material.

### Types

There are a number of different types of retaining walls. The following three are most commonly used:

The GRAVITY wall, which is perhaps the most common type and requires no complicated reinforcing. It depends upon its own shape and weight to resist the earth pressure. It is the simplest to construct and for walls under 20 feet in height, is often the most economical.

The CANTILEVER reinforced wall in which the weight of the earth behind the wall is utilized to prevent overturning. This wall requires very heavy and careful reinforcing.

The COUNTERFORT wall, in which counterforts are built at short intervals, tying the floor portion, which is held down by the weight of the earth to the vertical portion of the wall.

### Foundation

Excavate to below frost line and to firm enough soil to withstand the pressure at the toe of the wall due to tendency to overturn.

### Size

A common rule for gravity walls is to make the base 4/10 to 5/10 as wide as the height of the wall. The front of the wall is usually given a slope, or batter, of 1 inch to 2 inches per foot of height. The back of the wall on the earth side should be preferably stepped.

### Forms

Forms may be constructed of 1½ inch or 2 inch lumber, held in place by 2 x 6 inch bracing and struts. The struts are nailed to stakes driven in the ground, as shown in Fig. 93.

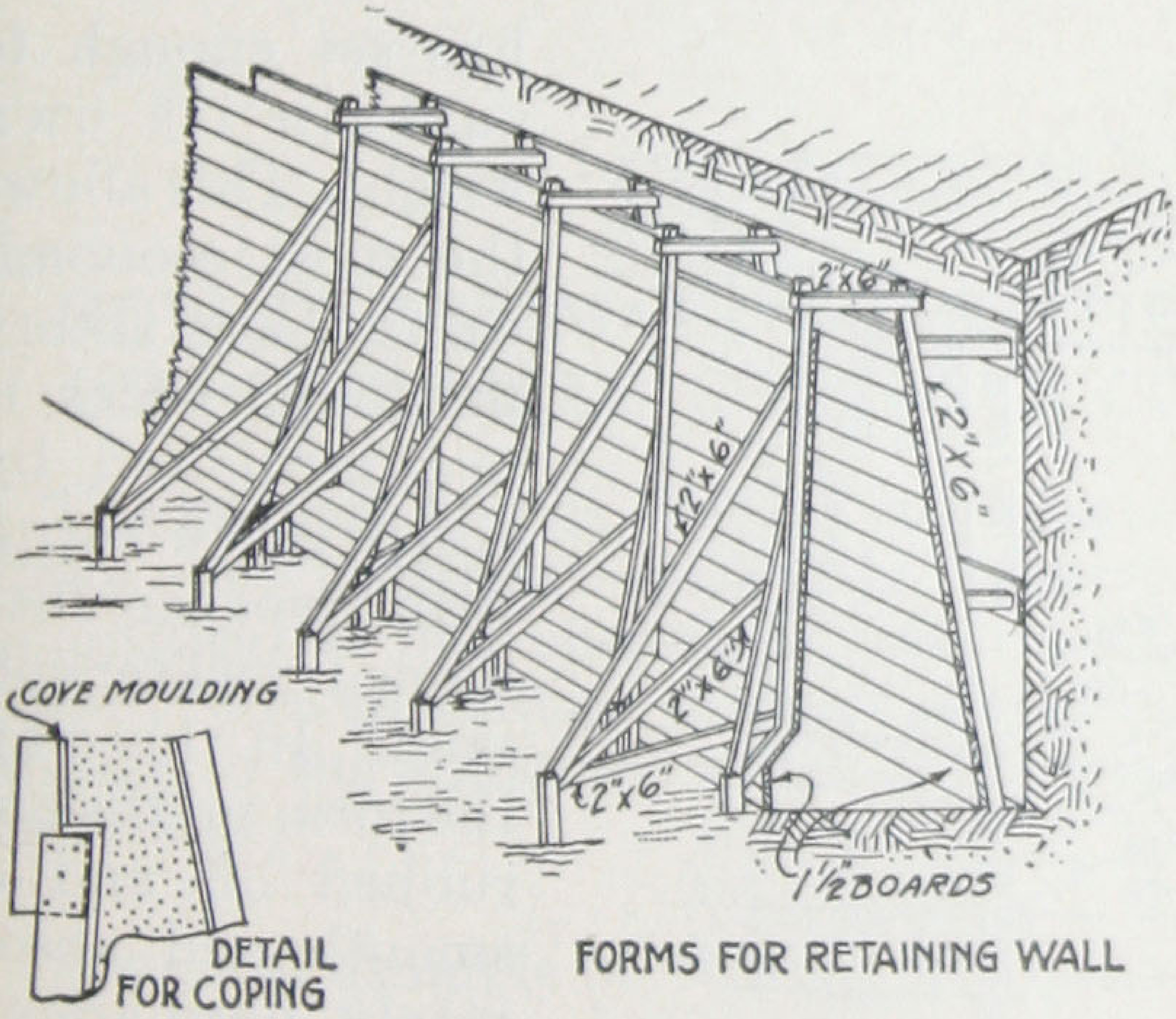



Fig. 93.—Forms for gravity type retaining wall.

Coping always adds to the appearance of a concrete retaining wall. The coping projects 2 or 3 inches beyond the face, and is from 8 to 18 inches high, depending on the height of the wall. Its corners should be beveled or rounded, which is done by nailing a triangular strip or a cove-molding in the forms. It is better to build the coping at the same time as the rest of the wall, but if this is not possible, it can be done later.

## Drainage

Of especial importance is the drainage of water from the earth held by the wall. A layer of loose stones, gravel, or cinders, should be placed directly behind the wall, and weep holes from 6 to 10 feet apart should be provided. These can be made by inserting during construction 3 or 4-inch drain tile at the earth line at the face of the wall, as shown in Figure 94. Back filling should be carefully done, soil being thoroughly compacted. The earth is deposited in layers about 8 inches thick, depending on the character of the material, each layer being tamped before the next layer is placed.

## Finish

Since retaining walls do not withstand any pressure during construction, the forms can be stripped as soon as the concrete

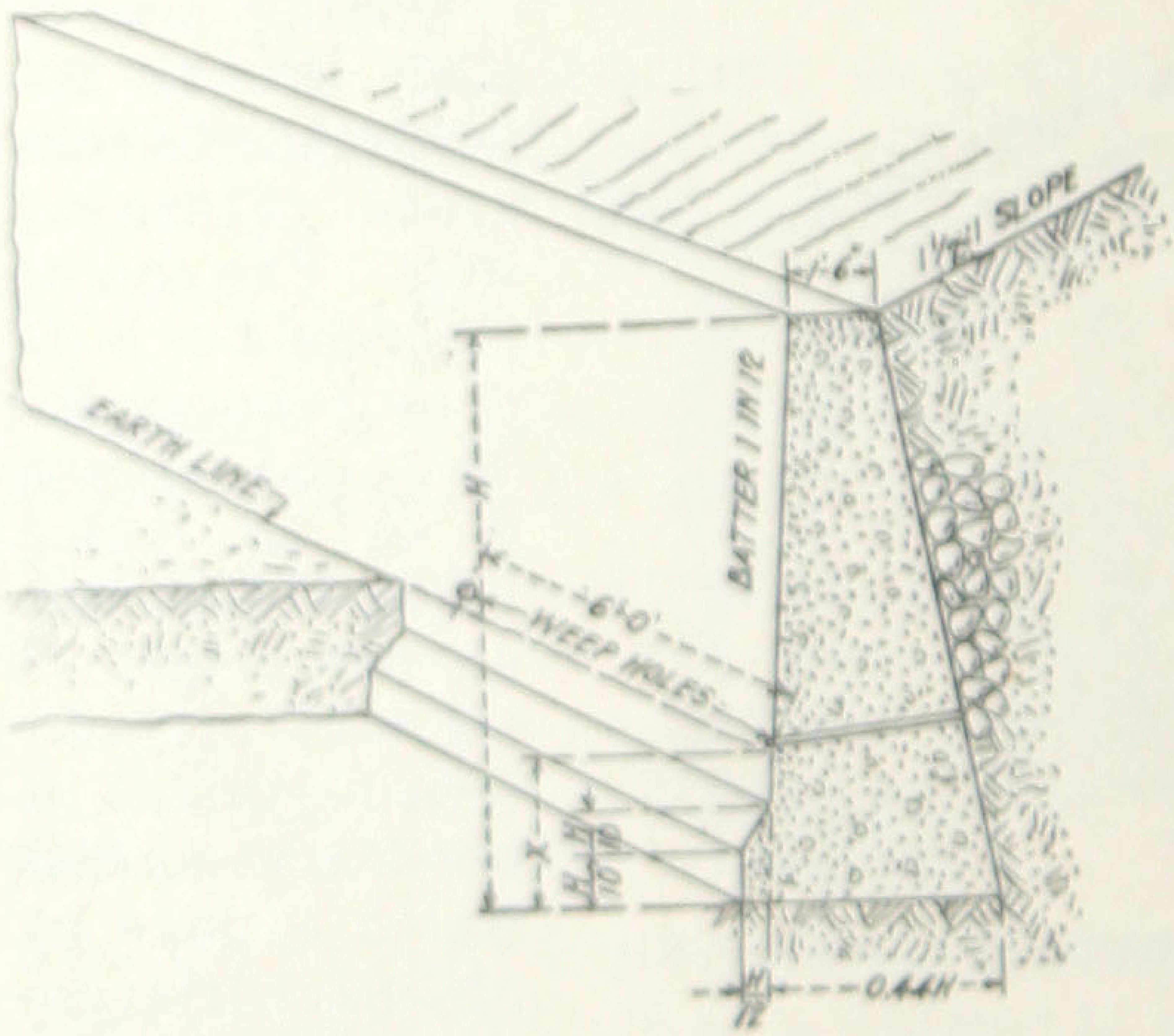



Fig. 94.—Construction details for gravity type retaining wall.

has set enough to sustain its own weight. This allows the most economical and satisfactory finishing, which is accomplished by simply rubbing with a wooden float dipped in water and sand. In this way the form marks are rubbed off and a smooth and absolutely permanent surface is obtained.

## CEMENT PRODUCTS

The name "cement products" is given to concrete building units which are small enough to pre-cast (cast before setting in place) in a factory.

In this class are:

| | |
|---|---|
| Building Block | Concrete Silo Staves |
| Brick | Drain Tile and Pipe |
| Sills and Lintels | Floor Tile |
| Building Trim | Cement Shingles |
| Roof and Wall Tiles | Fence Posts |
| Blocks for Stucco | Sign and Lamp Posts |

To properly manufacture cement products it is necessary to have a good plant, well equipped with the necessary moulds and machines. Unless you have such a plant, it will be best to purchase the cement products you require from an established manufacturer in your locality.

For further information on cement products and the names of manufacturers of moulds and machines, write The Atlas Portland Cement Company.

# CHAPTER V.

## HOW TO ESTIMATE QUANTITIES AND COSTS ON REINFORCED CONCRETE CONSTRUCTION

The purpose of this chapter is to describe in detail how to "take off" material quantities (concrete, form and steel quantities) in one operation from construction plans and to follow these quantities through a systematic routine of unit pricing to the summary which gives final erection costs of a structure.

A typical example of "taking off" quantities from the plans and assigning unit prices is given for an interior bay 20 x 20 feet of a reinforced concrete building. The details accompanying this text are representative of plans that are furnished by architects to contractors for estimating costs and placing bids of complete erection.

The "take off" must necessarily follow certain structural divisions, as the unit items upon which it is possible to place a price vary with different parts of the structure as (1) footings, (2) columns (exterior and interior columns listed separately as they vary structurally) and (3) floor construction (divided into slabs, beams and girders because the prices of concrete, form and steel units vary with these members).

The pricing units, such as the cubic foot or yard of concrete, the square foot of contact area for the forms and the pound for the steel, must also be observed. It is customary to keep each floor separate as an aid to checking.

In the summary of floor quantities consideration must also be given to the number of times each form can be used over without alteration. In the building illustrated in Fig. 95, the slab, beam and girder forms for the second and third floor are the same as the first, so the only form change is for erecting and stripping.

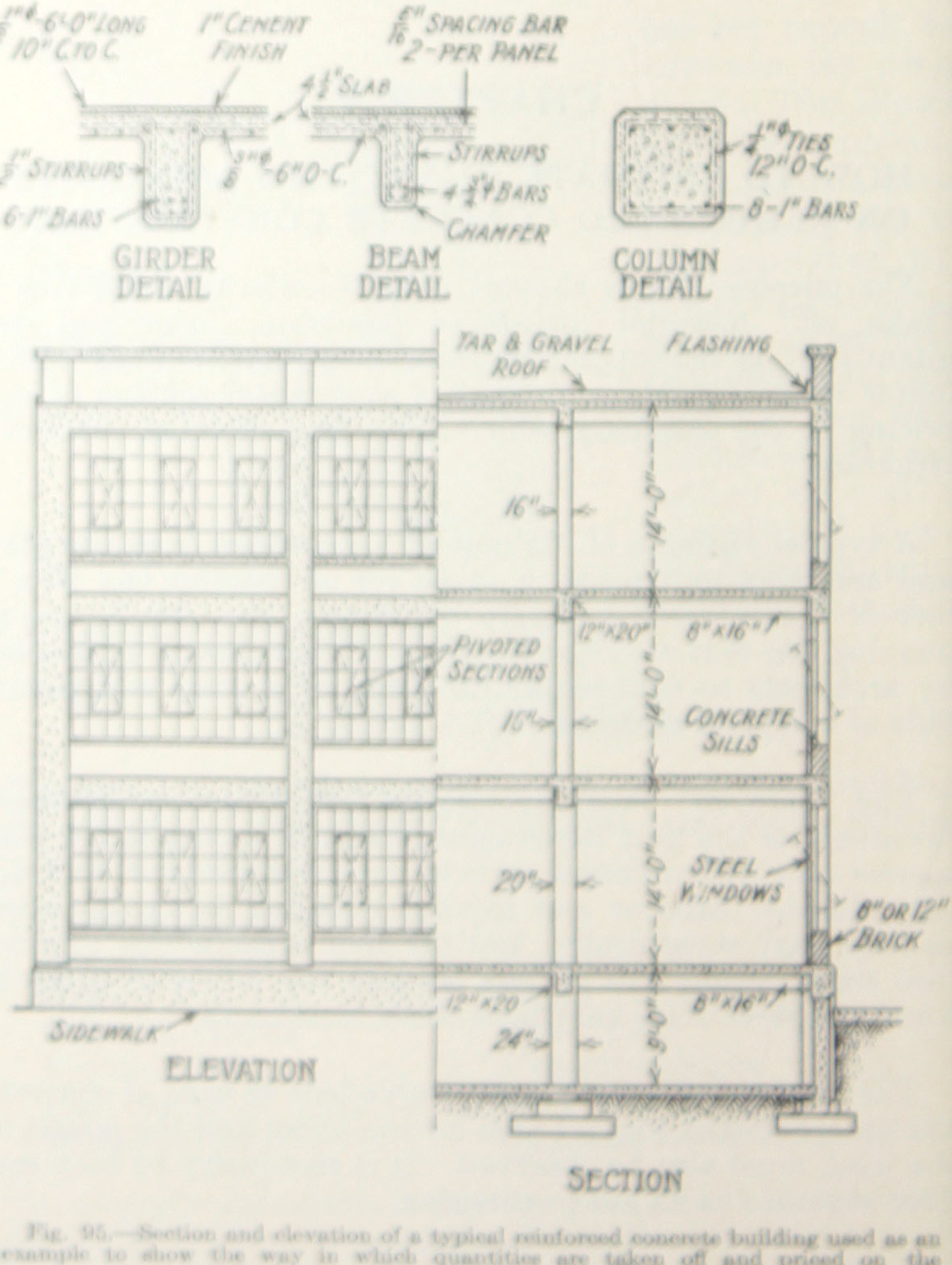


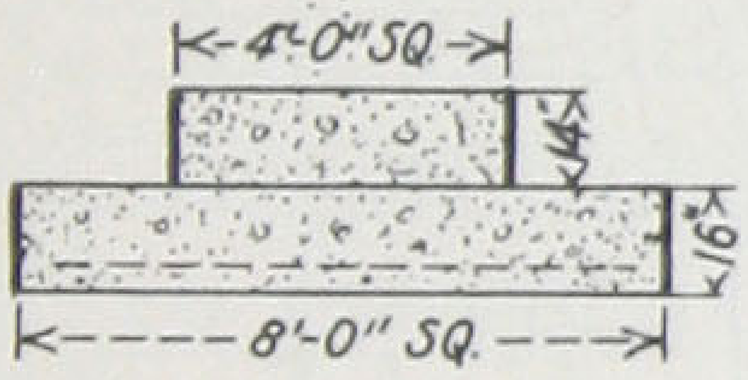
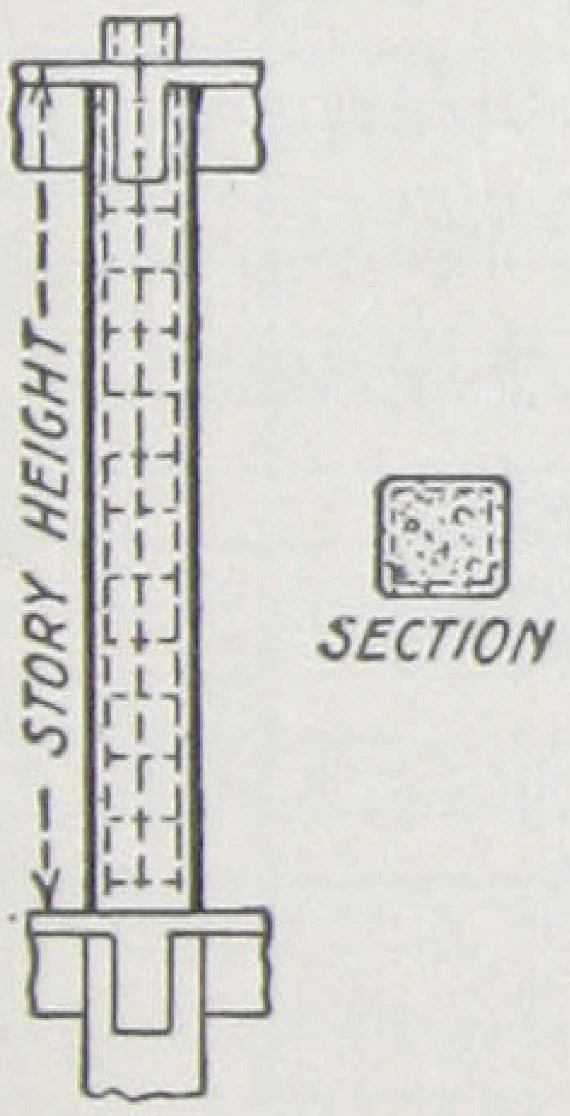
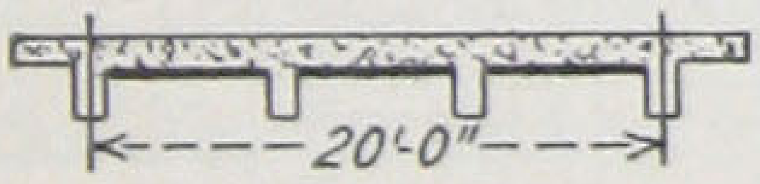

Fig. 95.—Section and elevation of a typical reinforced concrete building used as an example to show the way in which quantities are taken off and priced on the accompanying schedule sheets.

## TAKE OFF SHEET

CONTRACTOR'S NAME

SHEET #1

DATE: JOB: 3 STORY AND B'SM'T. FACTORY

| | CONCRETE & FORMS | | | | | | STEEL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FOOTINGS | 8'-0" | 8'-0" | 1'-4" | | 85 | | SIZE | NO | L'NGTH | WT. | | |
|  | 4'-0" | 4'-0" | 1'-2" | | 19 | | 3/4"φ | 24 | 7'-4" | 1.5 | 264 | |
| | | TOTAL CONC. | | | 104 | X | 1 | 8 | 3'-0" | 2.67 | 64 | |
| | 8'-0" | 4 | 1'-4" | | 43 | | | TOTAL STEEL | | | 328 | X |
| | 4'-0" | 4 | 1'-2" | | 19 | | | | | | | |
| | | TOTAL FORMS | | | 62 | X | | | | | | |
| COLUMNS — BSMT. | 2'-0" | 2'-0" | 9'-4" | | 32 | | 1 | 8 | 10'-10 | 2.67 | 232 | |
|  | | TOTAL CONC. | | | 32 | | 1/4 | 10 | 7'-6" | .16 | 12 | |
| | 2'-0" | 4 | 9'-4" | | 75 | | | | STEEL | | 244 | |
| | | TOTAL FORMS | | | 75 | | | | | | | |
| FIRST | 1'-8" | 1'-8" | 13'-7½ | | 38 | | 7/8 | 8 | 15'-0 | 2.04 | 245 | |
| | | | CONC. | | 38 | | 1/4 | 14 | 6'-6 | .16 | 15 | |
| | 1'-8" | 4 | 13'-7½ | | 91 | | | | STEEL | | 260 | |
| | | | FORMS | | 91 | X | | | | | | |
| SECOND | 1'-4" | 1'-4" | 13'-7½ | | 24 | | 7/8 | 4 | 15'-0 | 2.04 | 123 | |
| | | | CONC. | | 24 | | 1/4 | 14 | 4'-6 | .16 | 11 | |
| SECTION | 1'-4" | 4 | 13'-7½ | | 73 | | | | STEEL | | 134 | |
| | | | FORMS | | 73 | | | | | | | |
| THIRD | 1'-4" | 1'-4 | 13'-7½ | | 24 | | 3/4 | 4 | 14'-0 | 1.5 | 84 | |
| | | | CONC. | | 24 | | 1/4 | 14 | 4'-6 | .16 | 11 | |
| STORY HEIGHT | 1'-4" | 4 | 13'-7½ | | 73 | | | | STEEL | | 95 | |
| | | | FORMS | | 73 | | | | | | | |
| | TOTAL CONC. IN COL'S | | | | 123 | X | TOTAL STEEL IN COL'S | | | | 733 | X |
| | TOTAL FORMS | | | | 312 | X | | | | | | |
| FIRST FLOOR SLAB | 20'-0 | 20'-0 | 0'-4½ | | 150 | | 3/8 | 40 | 23'-0 | .37 | 347 | |
|  | | | CONC. | | 150 | | 5/16 | 6 | 23'-0 | .26 | 37 | |
| 20'-0" | 20'-0 | 20'-0 | 1 | | 400 | | | | STEEL | | 384 | |
| | | | FORMS | | 400 | | | | | | | |
| FIRST FLOOR BEAMS | 0'-8" | 1'-4 | 20'-0 | 3 | 53 | | 3/4 | 2x3 | 22'-6 | 1.5 | 203 | |
|  | | | CONC. | | 53 | | 3/4 | 2x3 | 25'-3 | 1.5 | 228 | |
| | 2 | 1'-4" | 20'-0 | 3 | 160 | | 3/8 | 18'-3 | 3'-3 | .37 | 67 | |
| | | | FORMS | | 160 | | | | STEEL | | 498 | |
| FIRST FLOOR GIRDERS | 1'-0" | 1'-8" | 20'-0 | | 34 | | 1 | 3 | 23'-3 | 2.67 | 187 | |
|  | | | CONC. | | 34 | | 1 | 3 | 27'-0 | 2.67 | 216 | |
| | 2 | 1'-8" | 20'-0 | | 67 | | 1/2 | 18 / 20 | 8'-0 / 8'-0 | .67 | [illegible] | |
| | | | FORMS | | 67 | | | | STEEL | | 543 | |
| | TOTAL CONC. IN FLOOR | | | | 237 | | TOTAL STEEL IN FLOOR | | | | 1425 | |
| SECOND FLOOR SAME AS FIRST | | | | | | | | | | | | |
| THIRD FLOOR SAME AS FIRST | | | | | | | | | | | | |
| ROOF | FORMS SAME AS 1ST | | | | | | 3/8 | 30 | 23'-0 | .37 | 260 | |
| | CONCRETE | | | | | | 5/16 | 20 | 23'-0 | .26 | 120 | |
| | 20'-0" | 20'-0 | 0'-3½ | | 117 | | 3/4 | 3 | 22'-6 | 1.5 | 101 | |
| | 0'-8" | 1'-4" | 20'-0 | 3 | 53 | | 3/4 | 3 | 25'-3 | 1.5 | 114 | |
| | 1'-0" | 1'-8" | 20'-0 | | 34 | | 3/8 | 14x3 | 3'-3" | .37 | 51 | |
| | | | CONC. | | 204 | | 7/8 | 2 | 23'-0 | 2.04 | 94 | |
| | | | | | | | 7/8 | 2 | 26'-9 | 2.04 | 109 | |
| | | | | | | | 1/2 | 14 | 5'-0" | .67 | 47 | |
| | | | | | | | 1/2 | 10 | 6'-0 | .67 | 40 | |
| | | | | | | | | | STEEL | | 936 | |
| | TOTAL CONC. 1-2-3 & R. | | | | 922 | | TOTAL STEEL 1-2-3 & R. | | | | 5211 | |

 INDICATES THE CONCRETE QUANTITIES TAKEN OF IN THIS PART OF ESTIMATE.

——— INDICATES FORM QUANTITIES FOR SAME

**PRICING SHEET** SHEET #2

CONTRACTOR'S NAME

DATE: JOB: 3 STORY AND B'SM'T FACTORY

| ITEM | QUANTITY | UNIT | MATERIAL | LABOR |
|---|---|---|---|---|
| FOOTINGS CONCRETE MATERIALS * | 104 x 1/27 CU.YD. | 4.78 | 18.41 | |
| LABOR | " | 1.50 | | 5.77 |
| FORMS LUMBER † | 62 x 1/2 B.F. | .02 | .62 | |
| LABOR | 62 SQ.FT. | .08 | | 4.96 |
| STEEL MATERIALS | 328 LBS. | .04 | 13.12 | |
| LABOR | 328 " | .00 3/4 | | 2.46 |
| | | | 32.15 | 13.19 |
| | | | | |
| COLUMNS CONCRETE MATERIALS | 123 x 1/27 CU.YD. | 4.78 | 21.77 | |
| LABOR | " | 1.25 | | 5.69 |
| FORMS LUMBER | 91 x 4 B.F. | .03 | 10.92 | |
| LABOR | 312 SQ.FT. | .10 | | 31.20 |
| STEEL MATERIALS | 733 LBS. | .04 | 29.32 | |
| LABOR | 733 " | .00 3/4 | | 5.53 |
| | | | 62.01 | 42.42 |
| | | | | |
| FLOORS CONCRETE MATERIALS | 922 x 1/27 CU.YD. | 4.78 | 163.23 | |
| LABOR | " | 1.25 | | 42.69 |
| FORMS LUMBER | 400 x 6 B.F. | .03 | 72.00 | |
| LABOR MAKING 1ST FL. SLABS | 400 SQ.FT. | .05 | | 20.00 |
| " " BEAMS | 160 " | .12 | | 19.20 |
| " " GIRDER | 67 " | .10 | | 6.70 |
| ERECTING 1ST FL. | 400 " | .07 | | 28.00 |
| STRIPPING " " | 400 " | .04 | | 16.00 |
| ERECTING & STRIPPING 2-3 & RF. | 1200 " | .08 | | 96.00 |
| STEEL MATERIALS | 5211 LBS. | .04 | 208.44 | |
| LABOR | 5211 " | .00 3/4 | | 39.09 |
| | | | 443.67 | 267.68 |
| | | | | |
| PLANT FOR ABOVE | | | | |
| CONCRETE-FOOTING 104 MAT. | 1149 x 1/27 CU.YD. | .25 | 10.64 | |
| COL. 123 FLOORS 922 LABOR | " " | .10 | | 4.25 |
| 1149 | | | | |
| LUMBER 62 x 1/2 31 | | | | |
| FORM CLAMPS 91 x 4 436 MAT. | 2795 B.F. | .00 1/4 | 6.99 | |
| 400 x 6 = 2400 | | | | |
| 2795 | | | | |
| STEEL TIE WIRES & CHAIRS | 6372 LBS. | .00 3/4 | 4.78 | |
| 328 733 MAT. | | | 22.41 | 4.25 |
| 5211 | | | | |
| 6372 | | | | |
| | | | | |
| FINAL TOTALS | | | 660.24 X | 327.54 X |

**SUMMARY SHEET**

CONTRACTOR'S NAME

DATE. JOB: 3 STORY AND B'SM'T FACTORY

| ITEM. | MATERIAL | LABOR | TOTALS |
|---|---|---|---|
| TOTALS FROM PRICING SHEET | 660.24 | 327.54 | 987.78 |
| GENERAL EXPENSE MAT. 10% OF | 66.78 | | |
| LABOR 6% | | 44.39 | |
| | 649.02 | 371.93 | |
| CONTINGENCIES 10% OF TOTAL LABOR | | 37.19 | |
| | 649.02 | 409.12 | 1058.14 |
| PROFIT 5% | | | 52.91 |
| | | | |
| BID | | | $1111.05 |
| | | | |
| SHEET #3 | | | |

This same condition of using the forms over applies to the columns; but in most buildings column sizes change slightly and the cost of cutting the larger columns down to size required for the higher stories is slight. It is therefore usual to average the column erection, stripping, and remaking as one amount.

Sometimes more than one full set of floor forms is necessary to speed up the work and the quantities for making and erecting are increased proportionately.

## Explanation of Schedule Sheets

Sheet No. 1—"Take-off Sheet" is the systematic tabulation of (1) quantities of concrete, (2) surface contact area of forms and (3) pounds of steel as taken from the plans furnished by the architect. All dimensions are taken off in feet and inches and the totals obtained in the unit upon which prices for the material required are obtained (concrete—cubic yards; forms—in square feet of contact area, and steel in lineal feet of different sizes to be reduced to pounds).

Sheet No. 2—"Pricing Sheet" is the systematic tabulation of quantities obtained from the totals of sheet No. 1 for the different structural divisions of the structure and the assigning of prices to these totals. Note that in assigning prices to these quantities there are two separate divisions—material costs and labor costs. It is well to maintain this division throughout the estimate schedule. Preliminary quotation can be obtained on material prices, but the labor cost is uncertain and should be carefully estimated and conservatively priced.

Sheet No. 3—"Summary Sheet" is the grouping of the totals from the pricing sheet No. 2 and the assigning of percentage to material and labor costs for general job expenses, contingencies and profit. The total of summary items gives bid price for the job.

# QUANTITIES OF CEMENT MORTAR FOR BRICK AND HOLLOW TILE WORK

The mortar commonly used for laying brick, tile and stone is made of one part cement and 3 parts sand. For white joints, Atlas White (see page 146) is used with white sand or white crushed marble in the above proportions. If colored joints are desired coloring matter is added to the mortar. Hydrated lime may be added if desired. Many contractors prefer to add lime because it makes the mortar work more easily under the trowel and allows it to spread better. The amount of lime to be used runs from 10% to 20% by volume of cement, and should not exceed 20%. The size of joint generally used is from three-eighths inch to one-half inch. Different kinds of joints are shown in Fig. 96.

Brick work is estimated by finding the number of square feet of wall surface and allowing 21 common brick per square foot for a wall 12 inches thick. The other thicknesses of wall are figured in proportion. Contractors give figures ranging from 675 to 800 brick to a barrel of cement, or an average of about 750.

The table on page 137 shows the amount of cement and sand required for laying brick and tile for joints of average three-eighths inch thickness.

To prevent mortar drippings from adhering to brick, dip the face of the brick before laying, in a soft soap solution.

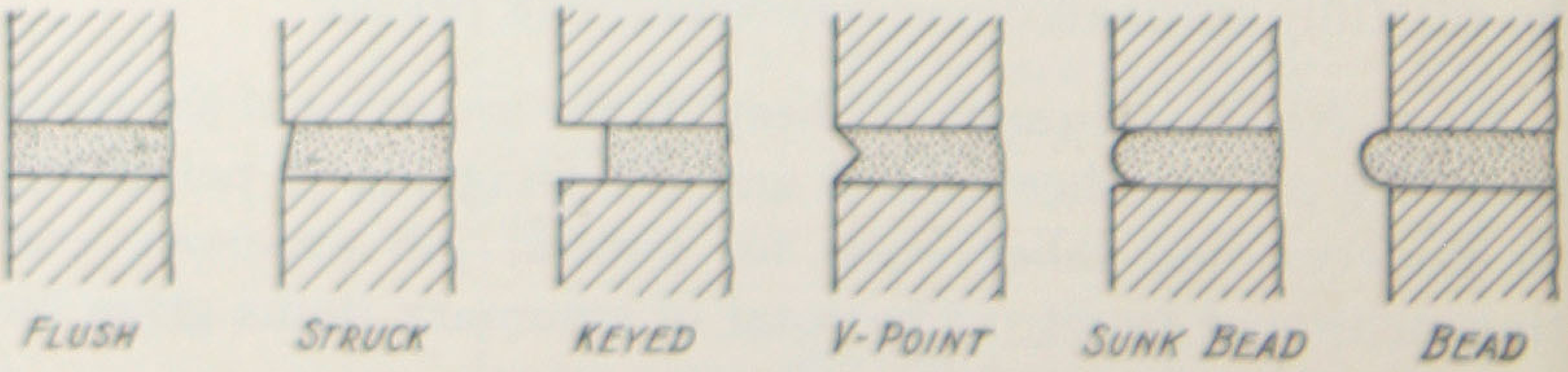



Fig. 96.—Types of mortar joint for brick work.

## TABLE 31
### Quantities of Cement and Sand Needed for One Cubic Yard of Mortar

| PROPORTIONS BY PARTS | | Barrels of Cement | Cubic Yards of Sand |
|---|---|---|---|
| Cement | Sand | | |
| 1 | 0 | 8.31 | |
| 1 | 1 | 4.88 | 0.72 |
| 1 | 1½ | 3.87 | 0.86 |
| 1 | 2 | 3.21 | 0.95 |
| 1 | 2½ | 2.74 | 1.01 |
| 1 | 3 | 2.39 | 1.06 |
| 1 | 4 | 1.90 | 1.13 |

## TABLE 32
### *QUANTITIES OF MORTAR, CEMENT AND SAND FOR LAYING 1000 BRICK

| Width of Joint | Cu. Ft. of Mortar | 1:2 Mortar | | 1:2½ Mortar | | 1:3 Mortar | | 1:3½ Mortar | |
|---|---|---|---|---|---|---|---|---|---|
| | | Cement Bbls. | Sand Cu. Yd. | Cement Bbls. | Sand Cu. Yd. | Cement Bbls. | Sand Cu. Yd. | Cement Bbls. | Sand Cu. Yd. |
| ¼ in. | 10 | 1.2 | 0.35 | 1.0 | 0.37 | 0.9 | 0.39 | 0.8 | 0.41 |
| ⅜ " | 15 | 1.8 | 0.53 | 1.5 | 0.56 | 1.3 | 0.59 | 1.2 | 0.61 |
| ½ " | 18 | 2.1 | 0.63 | 1.8 | 0.67 | 1.6 | 0.71 | 1.4 | 0.73 |
| ⅝ " | 22 | 2.6 | 0.77 | 2.2 | 0.82 | 1.9 | 0.86 | 1.7 | 0.90 |

* Note:—In using this table, bear in mind that quantities for brick work are only approximate, because there is sure to be considerable variation in thickness of joints and in the size of brick.

## CONCRETE BUILDING BLOCK AND CLAY TILE

| | Cement for Laying 1000 1:3 Mortar | Sand for Laying 1000 1:3 Mortar | Number of Block to 100 Sq. Ft. of Wall Surface |
|---|---|---|---|
| Concrete Block 8 x 8 x 16........ | 4.1 bbls. | 1.75 cu. yds. | 112 |
| Clay Tile† 3, 4, or 6 in. Partition. | 2.3 bbls. | 1.03 cu. yds. | |
| Clay Tile†—Load Bearing: | | | |
| 6 x 12 x 12............... | 2.9 bbls. | 1.29 cu. yds. | 100 |
| 8 x 12 x 12............... | 3.5 bbls. | 1.55 cu. yds. | 100 |
| 12 x 12 x 12............... | 4.6 bbls. | 2.06 cu. yds. | 100 |

†This information on Clay Tile was furnished by The Hollow Building Tile Association.

## TABLE 33

## QUANTITIES OF MATERIAL FOR CONCRETE

### Materials for One Cubic Yard of Rammed Concrete Based on Using Pebbles or Crushed Stone with Dust Removed

| Mixture | Bbls. Cement (4 bags per bbl.) | Cu. Yds. Sand | Cu. Yds. Pebbles or Stone |
|---|---|---|---|
| 1:1½:2½ | 2.09 | 0.46 | 0.77 |
| 1:1½:3 | 1.91 | 0.42 | 0.85 |
| 1:2:3 | 1.74 | 0.52 | 0.77 |
| 1:2:3½ | 1.61 | 0.48 | 0.83 |
| 1:2:4 | 1.51 | 0.45 | 0.89 |
| 1:2½:4 | 1.39 | 0.51 | 0.82 |
| 1:2½:5 | 1.24 | 0.46 | 0.92 |
| 1:3:5 | 1.16 | 0.52 | 0.86 |
| 1:3:5½ | 1.11 | 0.49 | 0.90 |
| 1:3:6 | 1.06 | 0.47 | 0.94 |

(From Taylor & Thompson's "Concrete, Plain and Reinforced.")

## TABLE 34

### Average Weights of Aggregates Used for Concrete

Size 1½ inch down to ¼ inch—dust screened out.

| | Lbs. per Cu. Yd. |
|---|---|
| Sand | 2430–2565 |
| Pebbles | 2800 |
| Limestone | 2400 |
| Granite | 2500 |
| Trap Rock | 2700 |

## TABLE 35

### Average Weight per Cubic Foot of Concrete in Place

| | Pounds per Cubic Foot |
|---|---|
| Gravel Concrete | 150 |
| Limestone Concrete | 150 |
| Trap Rock Concrete | 155 |
| Cinder Concrete | 112 |

## TABLE 36

### Typical Compressive Strength Test of Concrete using a good grade of commercial aggregates and a medium consistency

| Mixture | 7 Days | 28 Days | 6 Months |
|---|---|---|---|
| | Lbs. per sq. in. | Lbs. per sq. in. | Lbs. per sq. in. |
| 1:1½:3 | 1600 | 2700 | 3700 |
| 1:2:4 | 1100 | 2100 | 3000 |
| 1:2½:5 | 800 | 1600 | 2100 |
| 1:3:6 | 500 | 1300 | 1800 |

## TABLE 37

### COVERING CAPACITY OF MORTAR AND STUCCO

### Area Covered by One Barrel (4 Bags) of Cement in Various Mixes

| MIX Parts by Volume | | THICKNESS OF COAT | | | | |
|---|---|---|---|---|---|---|
| | | ¼ Inch | ⅜ Inch | ½ Inch | ¾ Inch | 1 Inch |
| Cement | Sand | Sq. Ft. | Sq. Ft. | Sq. Ft. | Sq. Ft. | Sq. Ft. |
| 1 | 1 | 266 | 177 | 133 | 89 | 66 |
| 1 | 1½ | 336 | 226 | 168 | 112 | 84 |
| 1 | 2 | 404 | 270 | 202 | 135 | 101 |
| 1 | 2½ | 472 | 314 | 236 | 157 | 118 |
| *1 | 3 | 542 | 362 | 271 | 181 | 136 |
| 1 | 3½ | 612 | 408 | 306 | 204 | 153 |
| 1 | 4 | 682 | 455 | 341 | 227 | 171 |

### Area Covered by One Cubic Yard of Sand in Various Mixes

| MIX Parts by Volume | | THICKNESS OF COAT | | | | |
|---|---|---|---|---|---|---|
| | | ¼ Inch | ⅜ Inch | ½ Inch | ¾ Inch | 1 Inch |
| Cement | Sand | Sq. Ft. | Sq. Ft. | Sq. Ft. | Sq. Ft. | Sq. Ft. |
| 1 | 1 | 1800 | 1200 | 900 | 600 | 450 |
| 1 | 1½ | 1508 | 1006 | 754 | 503 | 377 |
| 1 | 2 | 1364 | 910 | 682 | 455 | 341 |
| 1 | 2½ | 1282 | 855 | 641 | 427 | 321 |
| *1 | 3 | 1222 | 815 | 611 | 407 | 306 |
| 1 | 3½ | 1178 | 785 | 589 | 393 | 294 |
| 1 | 4 | 1148 | 765 | 574 | 383 | 287 |

*1:3 is the mix most used for stucco work.

NOTE: The above areas are calculated for average sand and with no allowance for waste. In estimating, allowance should be made for waste. When figured for stucco, the loss of mortar in forming the keys behind the lath for the first coat should be taken into account.

## TABLE 38
## AMOUNT* OF MIXING WATER FOR CONCRETE

| Proportions | | | Mixing Water Required per Bag | | Mixing Water Required per Cubic Yard | |
|---|---|---|---|---|---|---|
| Cement | Sand | Stone | Minimum (gallons) | Maximum (gallons) | Minimum (gallons) | Maximum (gallons) |
| 1 | 1½ | 3 | 5½ | 6 | 42 | 46 |
| 1 | 2 | 3 | 5¾ | 6¼ | 40 | 43½ |
| 1 | 2 | 4 | 6 | 6½ | 36 | 39 |
| 1 | 2½ | 5 | 7¼ | 7¾ | 36 | 38½ |
| 1 | 3 | 6 | 8¼ | 8¾ | 35 | 37 |

## AMOUNT* OF MIXING WATER FOR CONCRETE FLOORS, ROADS AND PAVEMENTS

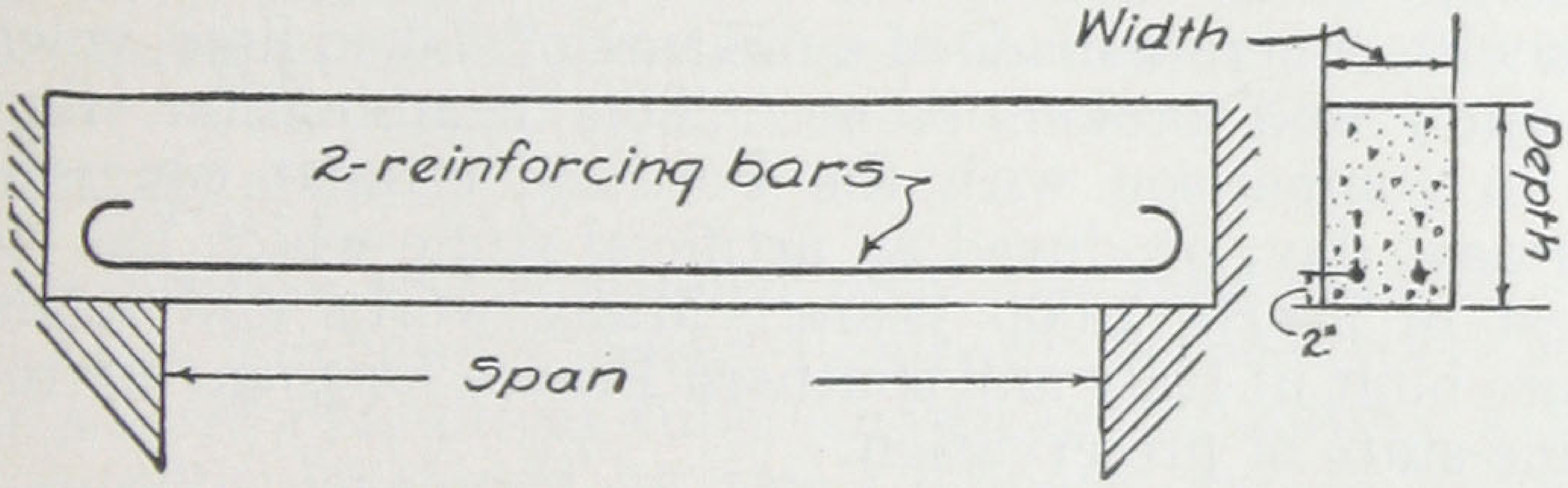
1:2:3 Mixture—One Course

| Average Thickness | For 100 Square Feet | | For 1,000 Square Yards | |
|---|---|---|---|---|
| | Minimum (Gals.) | Maximum (Gals.) | Minimum (Gals.) | Maximum (Gals.) |
| 4 inches | 49 | 53 | ........ | ........ |
| 5 inches | 62 | 67 | ........ | ........ |
| 6 inches | 74 | 80 | 6,700 | 7,250 |
| 7 inches | .. | .. | 7,750 | 8,430 |
| 8 inches | .. | .. | 8,870 | 9,650 |
| 9 inches | .. | .. | 10,000 | 10,880 |

*Obviously, it is impossible to more than approximate the amounts of water required, since a number of changeable conditions may greatly ffect the quantity used. Grading of aggregate, amount of water in sand and stone, consistency of mix, etc., are all influencing factors.

Note: It is advisable to estimate generously on the amount of water required for concrete work. There will be some wastage, and in addition, water will be required for boiler, if mixer is steam-driven; for washing out forms and for sprinkling and curing, especially for floors, sidewalks and pavements.

## TABLE 39
## REINFORCED CONCRETE LINTELS*




### SUPPORTING 8-INCH MASONRY WALLS

| Size of Lintel, Width x Depth | Span (Width of Opening) | | | | | |
|---|---|---|---|---|---|---|
| | 2′—4″ | 3′—0″ | 3′—10″ | 4′—6″ | 5′—2″ | 6′—0″ |
| | No. & Size of Bars | No. & Size of Bars | No. & Size of Bars | No. & Size of Bars | No. & Size of Bars | No. & Size of Bars |
| 6″ x 8″........ | 2—3/8″ | 2—1/2″ | ...... | ...... | ...... | ...... |
| 8″ x 8″........ | 2—3/8″ | 2—1/2″ | 2—3/4″ | ...... | ...... | ...... |
| 8″ x 10″........ | 2—3/8″ | 2—3/8″ | 2—1/2″ | 2—5/8″ | ...... | ...... |
| 8″ x 12″........ | ...... | 2—3/8″ | 2—1/2″ | 2—1/2″ | 2—5/8″ | 2—7/8″ |
| 8″ x 14″........ | ...... | ...... | 2—3/8″ | 2—1/2″ | 2—5/8″ | 2—5/8″ |

### SUPPORTING 12-INCH MASONRY WALLS

| Size of Lintel, Width x Depth | Span (Width of Opening) | | | | | |
|---|---|---|---|---|---|---|
| | 2′—4″ | 3′—0″ | 3′—10″ | 4′—6″ | 5′—2″ | 6′—0″ |
| | No. & Size of Bars | No. & Size of Bars | No. & Size of Bars | No. & Size of Bars | No. & Size of Bars | No. & Size of Bars |
| 8″ x 8″........ | 2—1/2″ | 2—3/4″ | ...... | ...... | ...... | ...... |
| 8″ x 10″........ | 2—3/8″ | 2—1/2″ | 2—3/4″ | ...... | ...... | ...... |
| 8″ x 12″........ | ...... | 2—1/2″ | 2—5/8″ | 2—5/8″ | ...... | ...... |
| 8″ x 14″........ | ...... | 2—3/8″ | 2—1/2″ | 2—5/8″ | 2—3/4″ | 2—1″ |

*Loads supported by lintels are difficult to definitely determine. The load depends upon the location of openings above the lintel, upon the loads coming on the wall above the lintel, if it is a load-bearing wall; and upon the arching action of the wall material itself. For this reason conservative assumptions have been used in preparing the table, and it should be adequate for any average condition.

All bars specified are round bars and they are to be hooked at the ends as shown in the sketch. When the opening is of another size than those given in the table, use the figures given for the next *largest* opening.

# PORTLAND CEMENT

Concrete dates back to the Romans. They secured good results with concrete made of a mixture of slaked lime, volcanic dust, sand and broken stone. This combination, though crude in comparison with the Portland cement concrete of the present day, produced an artificial stone which has stood the test of nearly 2,000 years. Many works and roads of concrete built in Italy and southern France long ago are today in a fine state of preservation.

Portland cement is of modern origin. Joseph Aspdin of Leeds, England, took out a patent under date of December 15th, 1824, for the manufacture of Portland cement. It was so called because it resembled in color a well-known limestone quarried on the Island of Portland, which was then considered the hardest stone known. The manufacture of Portland cement was begun in 1825, but the progress was slow until about 1850, when, through improved methods and general recognition of its merits as a building material, its commercial success was assured.

About this time the manufacturer of Portland cement was taken up by the French and Germans, and by reason of their more scientific methods, both the method of manufacture and the quality of the finished product was greatly improved. The first German Portland cement works were built in Stettin in 1855.

## Portland Cement in America

Portland Cement was first brought to the United States in 1865 and was first manufactured in this country in 1872.

The advance of the American Portland cement industry during the last two decades has been one of the marvels of the age. From a very small beginning the Americans came very rapidly to the front and with improved methods and appliances forged ahead until today the American Portland cements are superior to any others in the world. Not only this, but the section of the State of Pennsylvania, in which our Northampton Mill is located, produces more Portland cement today than all Germany and England combined.

In the early days in Germany and England, as well as in the United States, Portland cement was burned in dome kilns, much like those used for burning lime, the mixture in various stages being put into these kilns with alternate layers of coal or coke. The output of such a kiln was seldom more than 100 barrels a day.

This process was continued until the early nineties, when The Atlas Portland Cement Company began experimenting with a steel cylindrical tube, known as the rotary kiln. It was rapidly developed by this Company and is being used today for calcining Portland cement in every mill in the United States and is gradually being adopted in Germany and England. These rotary kilns produce from 500 to 3,000 barrels per day, according to their size. More than anything else they have been instrumental in reducing the cost of manufacture to such an extent as to make Portland cement an economical building material.

Modern Portland cement is a chemical compound. It is manufactured from a mixture of two materials, one a limestone or a softer material like chalk, which is nearly pure lime, and second, shale, which is like clay, or else clay itself. Portland cement can be manufactured anywhere that these ingredients are found. But it cannot be manufactured without the one material which is largely limestone, and the other material which is largely clay, and the two materials must be mixed in very exact proportions determined by tests, the proportions being changed as often as necessary to allow for any variation in the chemical composition of the materials.

In the Lehigh Valley, Pennsylvania, where a substantial proportion of the entire output of the country is manufactured, there are extensive natural deposits of what is known as cement rock, which contains the ingredients needed in practically the proper proportions for the manufacture of Portland cement.

To manufacture Portland cement the raw materials are quarried, crushed and pulverized, mixed in the proper proportions, and the pulverized raw materials of the correct chemical composition are then fed into rotary kilns, where the mixture is burned to what is known as cement clinker.

Briefly described, a rotary kiln is a steel cylinder 6 to 12 feet in diameter and from 60 to 250 feet in length. It is continuous in operation—the raw material is fed into one end and by reason of the inclined position of the kiln and its rotary motion, the material is passed into the lower end and discharged.

During the passage of this raw material from one end of the kiln to the other, perfect calcination is obtained by means of an air blast, carrying powdered coal, the coal being set on fire as it enters the kiln. The clinker resulting from the burning of the raw material in this way is then cooled and pulverized and becomes the Portland cement of commerce.

## ATLAS PORTLAND CEMENT

Wonderful as the advance of the general industry has been, the growth of The Atlas Portland Cement Company has been even more remarkable. Beginning in 1892 at Coplay, Pennsylvania, with a manufacturing capacity of 250 barrels per day, its production has steadily increased through the various plants at Northampton Pa.; Hannibal Missouri; Hudson, New York; Leeds, Alabama; and Independence, Kansas. Daily shipments of 300 cars or about 11,000 tons of Portland Cement, are not unusual.

At Northampton, the plant covers about 213 acres. When in full operation, the Northampton plant consumes about 9,000 tons of raw rock daily, and employs 2,700 men. These figures, which concern the Northampton plant alone, give an idea of the capacity of the Atlas plants as a whole. By virtue of its enormous production The Atlas Portland Cement Company is able to develop and retain in its service the most skilled operating talent in the Portland cement industry, which insures in Atlas a thoroughly reliable and uniform product.

The methods of manufacture of Portland cement developed and perfected by The Atlas Portland Cement Company have been continued with the greatest care and to such an extent that these methods are accepted as standard by practically every other cement manufacturing company. In the manufacture of Atlas Portland Cement, the raw materials are carefully selected, and carefully mixed after automatic weighing machines have weighed exactly the right quantity of cement

rock and the right quantity of limestone. These materials are then mixed thoroughly by automatic mixers, which are constantly controlled by chemists in charge of the operation, not only during the day, but night and day.

With this control, the mixture never varies. In fact, at the Atlas plants from the time the rock is quarried until the cement is packed into bags and barrels, the work is done by machinery controlled in all its stages by experts. In plain words, we manufacture cement scientifically and not by accident. The finished product also is constantly tested and the mill never operates for a moment without the control of the mill chemists.

One grade of cement only—the highest—is manufactured, and every barrel shipped from the Atlas mills meets all standard specifications for Portland cement, and also complies with Atlas specifications, under which each of our mills operates and which are more severe and more exacting than the requirements of standard specifications.

## ATLAS-WHITE NON-STAINING PORTLAND CEMENT

Atlas-White Portland Cement is a true Portland cement. Its chemical composition is practically identical with that of Atlas Portland Cement. The strength of Atlas-White is equal to that of gray Atlas, and is guaranteed to meet the standard requirements for Portland cement, It is, therefore, a true Portland cement that has the same physical characteristics as the gray Atlas, and may be used with the same manipulation and for the same class of work where a white color is desired.

Atlas-White was placed on the market for the purpose of supplying the demand for a high-grade white Portland cement that was non-staining and could be used where a white or light tone effect of coloring was wanted. Its non-staining property makes it desirable for setting and pointing fine textured stone such as marble, light granite, etc. It will not stain or streak these natural rocks, and they are as firmly cemented together when bedded or set in Atlas-White as if they were one solid stone.

Atlas-White is also used in all colored cement work where true color tones are desired. It is white, and therefore gives the true color value of color aggregates or coloring pigments. In all decorative cement work, either exterior or interior, Atlas-White has afforded the opportunity of color and soft tone effects never before realized in cement construction.

The use of Atlas-White for colored stucco and other purposes is explained in detail in other booklets issued by The Atlas Portland Cement Company, and these will be furnished upon request to those who are interested and are contemplating stucco work. What is said in this book applies to problems in the use of Atlas-White, as well as to Atlas Portland Cement.

In using Atlas-White it should be remembered that if a pure effect is desired, it will be necessary to use an aggregate (usually sand) with it that is also white.

*(The following pages outline the uses of Atlas Lumnite Cement, a product of our affiliated Company.)*

# CHAPTER VI.
## SPEEDY CONSTRUCTION WITH
## ATLAS LUMNITE CEMENT

Atlas Lumnite Cement is a hydraulic cement which develops in 24 hours greater strength than that developed by other building cements in 28 days. For concrete construction where speed is desirable or where emergency makes speed a necessity, LUMNITE Cement gives a service possible with no other material—full strength 28-day concrete in 24 hours.

The remarkable characteristics of Lumnite Cement are shown below in the report of tests made by the well known testing engineers—the Robert W. Hunt Company:

Soundness (Boiling Test)

Six hours without any signs of cracking, warping or scaling.

Setting Time

| | Initial Set | | Final Set | |
|---|---|---|---|---|
| | *Hrs.* | *Min.* | *Hrs.* | *Min.* |
| Vicat Needle........... | 4 | 20 | 5 | 45 |
| Gillmore Needle........ | 5 | 25 | 6 | 30 |

Fineness

Residue on No. 200 sieve 3.4 %

Tensile Strength

1:3 Ottawa Sand Mortar Briquettes

(Results in pounds per square inch)

| | 1 day | 2 days | 3 days | 7 days | 28 days | 3 mos. | 1 year |
|---|---|---|---|---|---|---|---|
| Average | 464 | 487 | 518 | 537 | 561 | 591 | 628 |

*Note—The Standard Specifications for Portland Cement of The American Society for Testing Materials (C9-26) require for that material, tensile strengths of only 225 pounds per square inch at 7 days and 325 pounds per square inch at 28 days.*

Compressive Strength of Mortar
2″ x 4″ cylinders—1:3 Standard Mortar
(Results in pounds per square inch)

| | 1 day | 2 days | 3 days | 7 days | 28 days | 3 mos. | 1 year |
|---|---|---|---|---|---|---|---|
| Average | 4725 | 4905 | 4940 | 4985 | 5004 | 5289 | 5724 |

*Note—The Tentative Specifications and Tests for Compressive Strength of Portland Cement Mortars (C9-16T) of the American Society for Testing Materials, require compressive strengths for that material of only 1200 pounds per square inch at 7 days and 2000 pounds per square inch at 28 days.*

Compressive Strength of Concrete
6″ x 12″ cylinders
(Results in pounds per square inch)

| Mix | 1 day | 2 days | 3 days | 7 days | 28 days |
|---|---|---|---|---|---|
| 1:1½:3 | 3287 | 4436 | 4656 | 4892 | 5639 |
| 1:2:4 | 2865 | 3351 | 3542 | 3860 | 3891 |
| 1:2½:5 | 2202 | 2269 | 2829 | 2934 | 2939 |
| 1:3½:7 | 1321 | 1364 | 1511 | 1565 | 1605 |

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Report of Tests
By E. L. Conwell and Company, Philadelphia, Pa.
Lumnite Cement Concrete Compression Tests
Cylinders, 6″ x 12″
(Each value represents strength in compression of 3 specimens in pounds per square inch)

| | 1:2:4 Mix | 1:3:6 Mix |
|---|---|---|
| 1 day | 3441 | 2071 |
| 2 days | 3818 | 2444 |
| 3 days | 4127 | 2598 |
| 7 days | 4391 | 2663 |
| 28 days | 4462 | 2691 |
| 6 mos. | 4846 | 2962 |
| 9 mos. | 5009 | 3317 |
| 1 year | 5072 | 3460 |

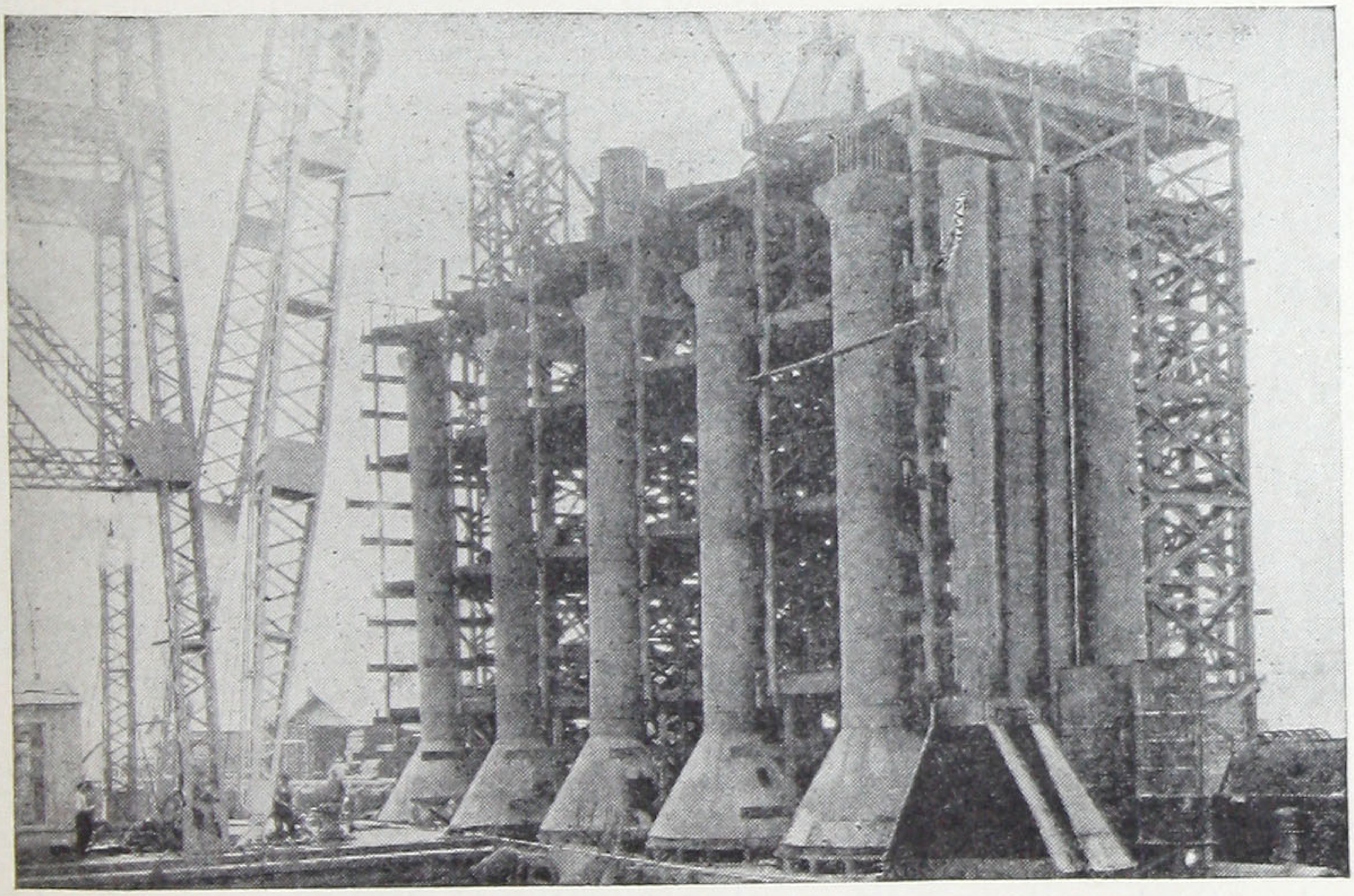

Fig. 97.—Enormous precast piers used at Bremerton, Washington. By means of Lumnite Cement these piers could be handled 24 hours after casting.

The high early strength of LUMNITE cement is due to its chemical composition, and results from the use of high-grade aluminum ore (Bauxite) as its principal raw material.

LUMNITE is not "quick-setting." It affords the usual time for mixing, transporting and pouring into forms, but after setting, its high strength develops with great rapidity.

Mixed with sand, stone and water it will form concrete. No other material is needed to give this 28-day strength within 24 hours.

The proportions of the mix will vary with the character of the sand and stone and the requirements of the work. *Rich mixes, especially in large masses, should not be used.* Users have found that mortar mixes richer than 1:2½ generally do not give best results in floor topping, sidewalk finishes, or

other uses, and that concrete mixes approximating 1:2:4 are satisfactory for most purposes.

Use the least amount of mixing water possible that will give plastic, workable concrete. Often the plasticity or workability of the concrete can be improved with less mixing water by varying the ratio of fine to coarse aggregates. Too much mixing water not only lowers the strength of the concrete but also makes it more porous and less durable.

The following table containing 24-hour compressive strength results on 1:2:4 LUMNITE cement concrete illustrates the effect of the amount of mixing water on the strength of the concrete:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| With | 5.26 | gals. of water | per | bag of | cement | 5253 | lbs. | per sq. in. |
| " | 6.00 | " | " | " | " | 4468 | " | " |
| " | 7.53 | " | " | " | " | 3258 | " | " |
| " | 9.41 | " | " | " | " | 1809 | " | " |

It is most important when measuring the amount of mixing water to allow for the moisture in the aggregates. The sand and gravel used with one bag of cement for a 1:2:4 concrete will contain from one to four gallons of water. Add only enough mixing water to make up the total amount specified.

Users have found that for most purposes from five to seven gallons of water, including the moisture in the aggregates, gives satisfactory results, but the smaller quantity will give greater strength and durability. Less than six gallons per sack of cement, including the moisture in the sand, should be sufficient for mortars.

Workability or plasticity is essential to good concrete, or otherwise the difficulty when placing the concrete will result in voids and other structural weaknesses. To obtain more workable concrete, vary the aggregates or proportions instead of adding more mixing water.

Hot water will hasten the setting of the cement, often causing "flash setting" and will result in concrete of less durability. Hot mixing water should never be used.

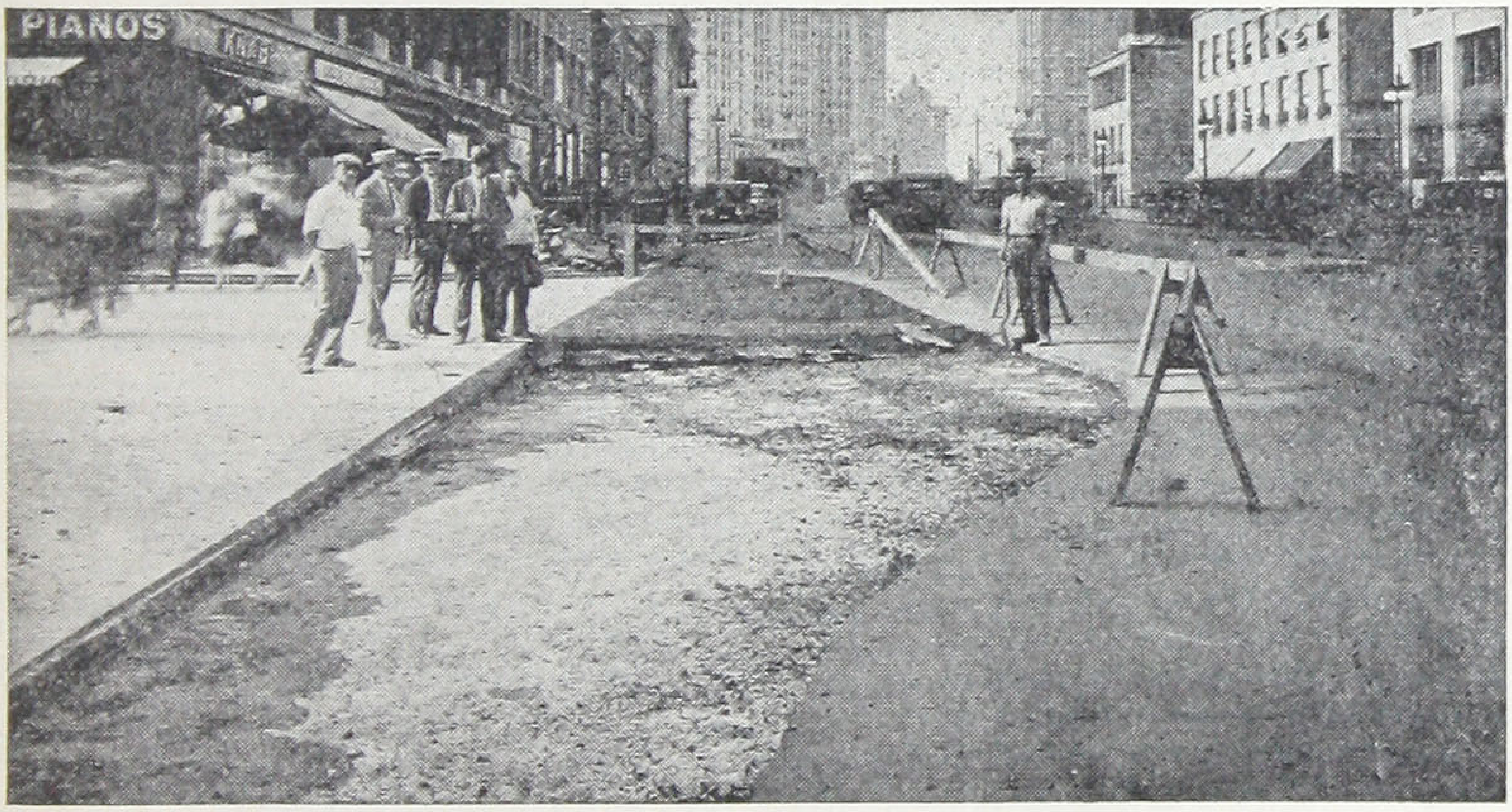


Fig. 98.—An example of the use of Lumnite Cement for street pavements. Pavement can be opened to traffic within 24 hours after laying, with consequent minimizing of traffic delays.

Because of its rapid hardening, LUMNITE requires all of its curing during the first 24 hours.

Curing water should be applied to all exposed surfaces as soon as the concrete is hard enough to resist the washing effect of water. If applied too soon, the water will combine with the unset or unhardened cement and thus have the same effect as too much mixing water. Curing water should not be applied too copiously at first. The curing of concrete by keeping it wet should be continued until 24 hours after the concrete was placed.

Under average condition, curing water will be required about six hours after mixing. In warm, dry weather, it may be required before six hours and in cold, damp weather as late as ten or twelve hours.

The curing water should be flowed on, sprinkled or sprayed. Do not cure by wet coverings, such as burlap, sawdust or sand, as this reduces surface strength and causes dusting.

Steam curing or heating to hasten the hardening of LUMNITE should not be used.

The application of curing water serves two purposes: It replaces the water lost from the surface by evaporation, which water is necessary for the hydration of the cement. It supplies water to the surface for evaporation which in turn accelerates the dissipation of the heat generated by the cement while hardening.

The rush often necessary to forestall winter can be avoided by the speed possible with LUMNITE. For work that must be done in cold weather, LUMNITE will be found of great advantage because it is less subject to injury from frost for two reasons: First—The rapid hydration or early hardening of LUMNITE cement (Chart No. 1) brings the concrete in a few hours to a point in its curing beyond the danger of frost attack.

Second—This rapid hardening, a chemical action, produces in LUMNITE cement concrete very considerable heat (Chart

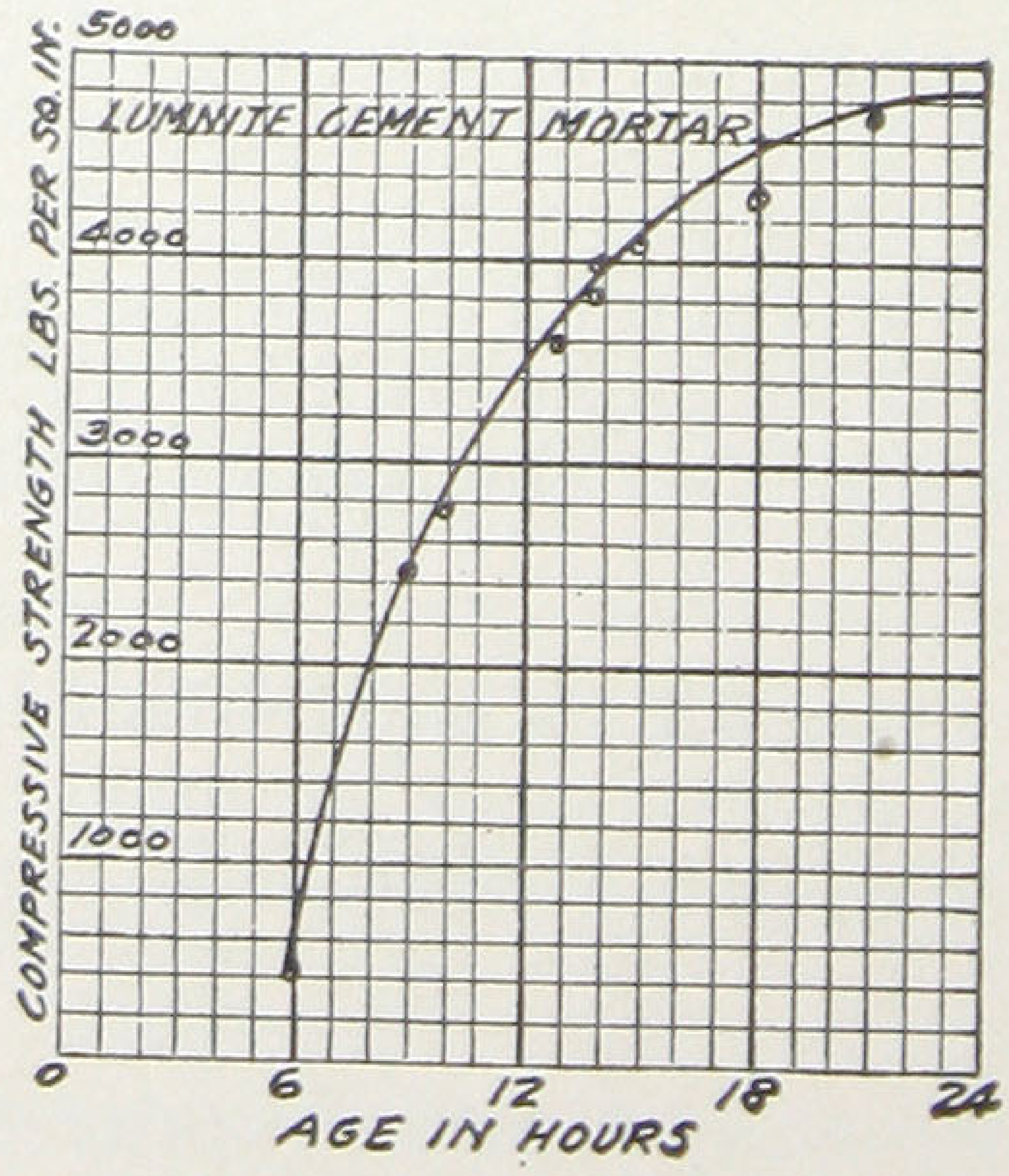


Chart No. 1

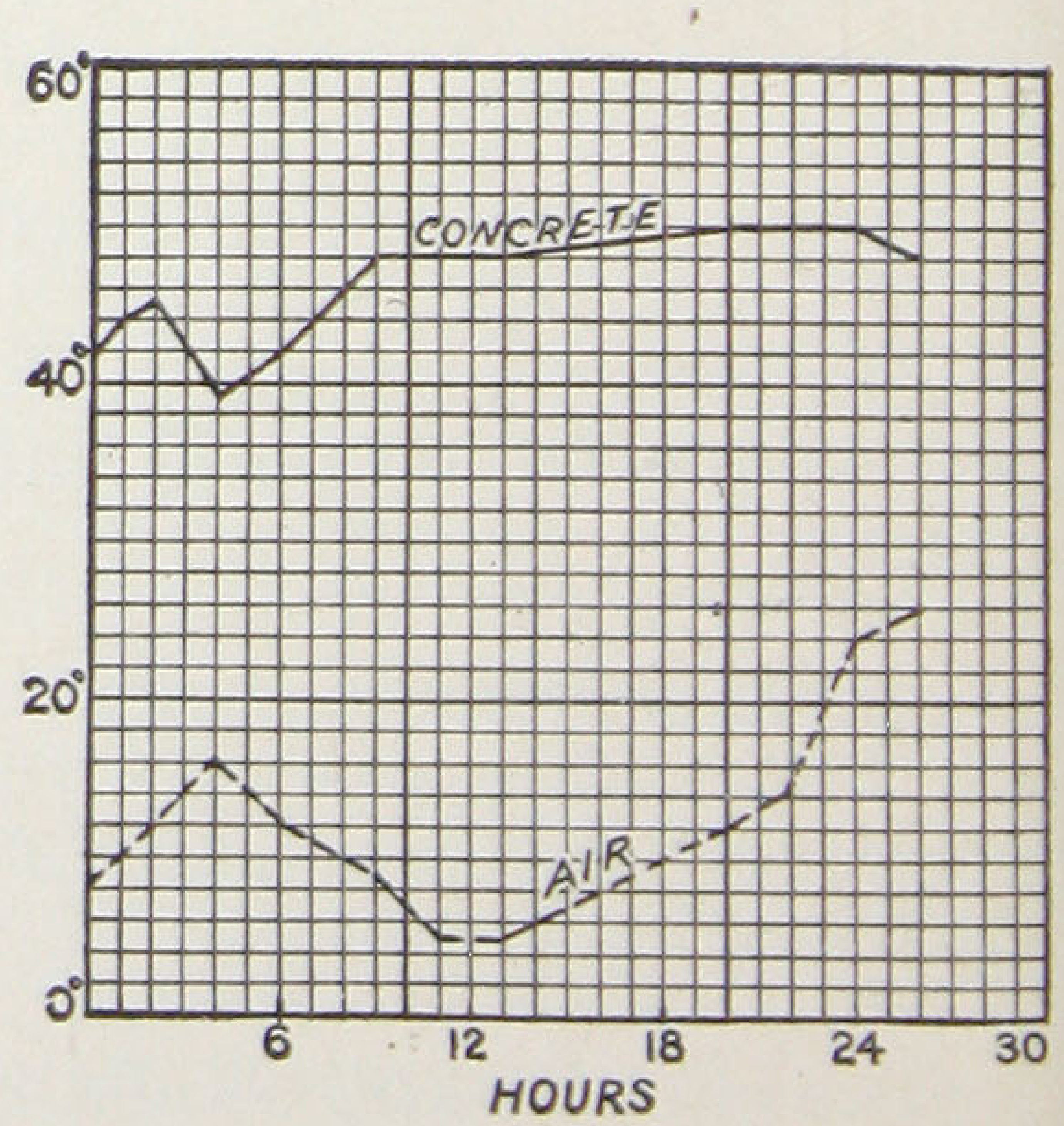


Chart No. 2

Fig. 99.—In chart Number 1 is shown the extraordinarily quick gain in strength of Lumnite Cement. Full strength is available at the end of 24 hours. Chart Number 2 shows high temperature maintained in Lumnite Cement concrete due to chemical action in spite of low temperature of surrounding air. This action is helpful in concreting in cold weather.

No. 2). This is an additional insurance against the attack of frost.

The test record in Chart No. 1 shows a compressive strength of LUMNITE cement mortar at twelve hours of approximately 3500 pounds per square inch. No other hydraulic cement—nor any combination of cement and accelerator—will give compressive strength anywhere near equal to this at the same period.

Chart No. 2 shows that on one job when the temperature of the air was 27° below freezing, the temperature of the LUMNITE concrete was 16° above freezing.

When using LUMNITE in cold weather, the aggregates should be free from frost. Better results are obtained if the concrete is at normal temperature (50 to 70° F.) when it leaves the mixer.

In moderately cold weather, LUMNITE concrete needs protection only until the concrete takes its set, that is, becomes hard; and even in extremely cold weather, protection is necessary only during the first 24 hours.

Heat should be used only to avoid freezing temperatures in the concrete. It should not be used to hurry the hardening of the concrete at any time. Curing water is necessary in cold weather only if the concrete surfaces appear to dry out during the first 24 hours.

In hot weather, LUMNITE cement should be stored in a cool place and should be protected from the direct rays of the sun either in storage or when piled at the work. Heat absorbed by the cement will cause it to become quick setting and will lower its strength.

Piles of stone and gravel in very hot weather should be cooled by sprinkling.

Exposed surfaces of freshly placed concrete should be protected from the direct rays of the sun to avoid too rapid drying out.

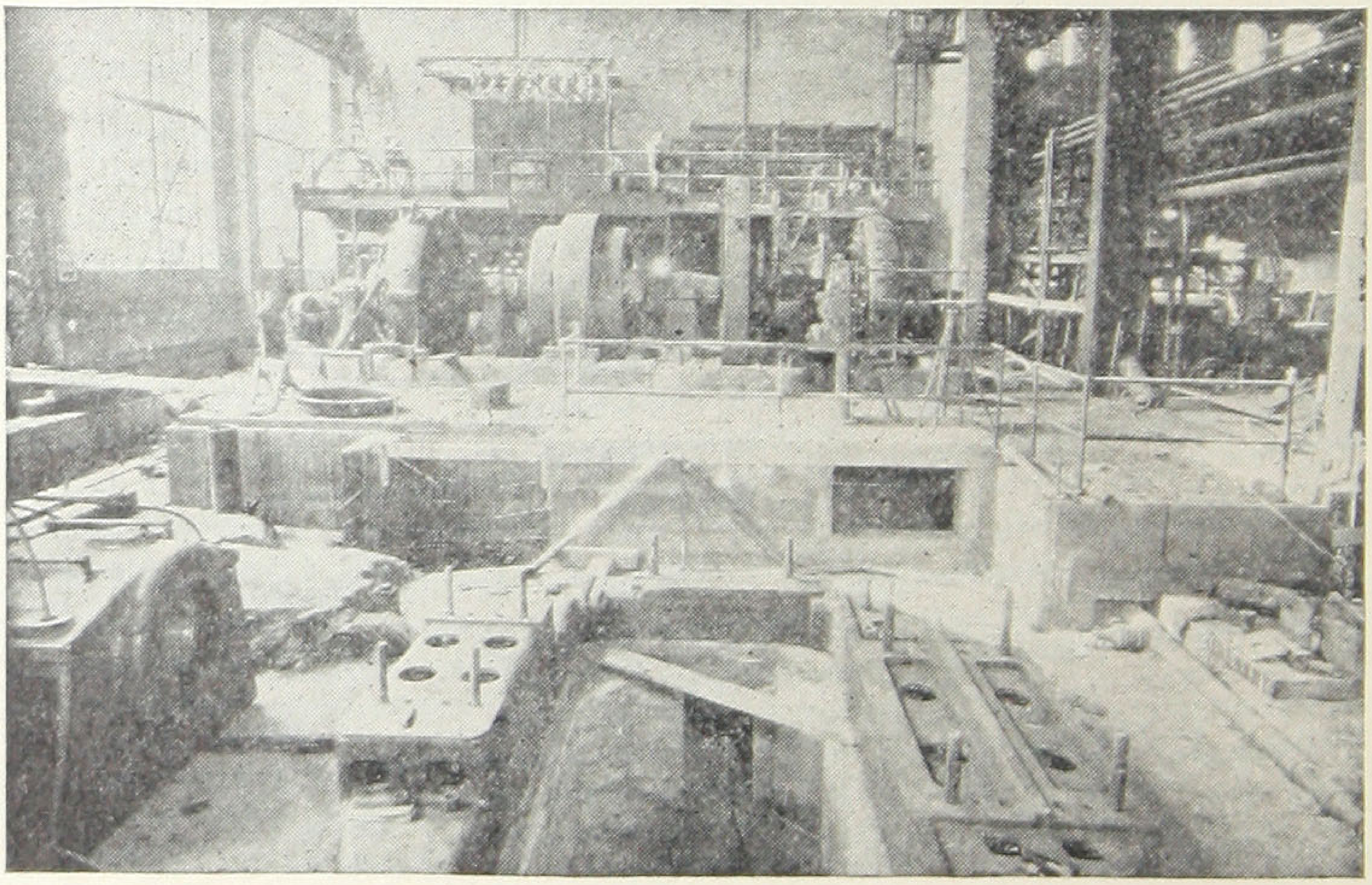

Fig. 100.—Large engine foundations made with Lumnite Cement permitting the installation of the heavy machinery loads within 24 hours after pouring.

Other cements, limes, anti-freezing compounds, accelerators and soluble compounds in general should not be mixed with LUMNITE.

LUMNITE cement mortar or concrete will bond well to old portland cement concrete. All of the old surface, including stained or weakened concrete, should be removed to good, sound concrete. This surface should then be brushed clean and thoroughly moistened. The wet surface of the old concrete should either be dusted with LUMNITE cement or thinly coated with a rich, creamy grout of LUMNITE cement immediately before placing the LUMNITE cement concrete.

LUMNITE top coats should not be applied over freshly placed portland cement concrete bases. Due to the difference in the rate of hardening of the two cements, the top coat may separate from the base.

LUMNITE in storage should be given the same careful protection against the absorption of moisture and pressure caking as is recommended for portland cement.

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# TABLES

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